City of Portsmouth, New Hampshire
Wastewater Master Plan

Technical Memorandum
TM 5
WWTF PROCESS AND SITING AND CSO ABATEMENT EVALUTIONS

Tasks:	5.1 through 5.11	
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EXECUTIVE SUMMARY

Technical Memorandum 5 (TM 5) is one in a series of interim deliverables prepared as part of the Wastewater Master Plan (WMP) for the City of Portsmouth, New Hampshire (the City). An overview of the WMP background and TM 5 in particular, is as follows:

- The City of Portsmouth currently owns and operates two wastewater treatment facilities (WWTF):
    - The Peirce Island (PI) WWTF is designed to treat 4.8 million gallons per day (MGD) on an average daily basis and provides advanced-primary treatment.
    - The Pease International Tradeport (PIT) WWTF is designed to treat 1.2 MGD is a secondary treatment facility that uses the sequencing batch reactor (SBR) process and provides BNR.
- In 2007, the U.S. Environmental Protection Agency (EPA) denied the renewal of the 301(h) waiver under which the PI WWTF was operating and issued a new National Pollutant Discharge Elimination System (NPDES) permit requiring secondary treatment. An Administrative Order was issued to set interim limits which the PI WWTF must meet until such time that a new secondary treatment process is constructed at the PI WWTF, or a new secondary treatment WWTF is constructed elsewhere.
- In addition to the new NPDES permit for the PI WWTF, it is anticipated that EPA will include a total nitrogen (TN) limit in future NPDES permits for both the PI WWTF and the PIT WWTF.

- The WMP includes an evaluation of required WWTF upgrades and combined sewer overflow (CSO) abatement measures. The WWTF upgrade evaluation consists of two parts: one evaluation of potential WWTF sites and a second evaluation of secondary treatment and nutrient removal processes. The evaluation of CSO abatement measures involves screening and selection of appropriate abatement controls and technologies.

- The evaluations of WWTF upgrades and CSO abatement measures are independent of one another; however, they are both dependent on the same potential flow scenarios:

  - Scenario 1: City wastewater continues to be treated on Peirce Island.
  - Scenario 2: City wastewater is split between the PI WWTF and the PIT WWTF
  - Scenario 3: City wastewater is not treated on Peirce Island; all wastewater is redirected to PIT or a new site

- The WWTF design basis for TM 5 is 8.9 MGD average daily flow, with the potential of 13.0 MGD as a maximum monthly flow.

- Site selection was the first step in the evaluation of WWTF upgrades. The space available at the PI WWTF site is limited. The existing PIT WWTF site could be expanded and upgraded to treat full build-out flow, but would require significant flow re-direction in the collection system. Therefore, locating a new WWTF at other sites in the Portsmouth area was evaluated. Sites qualified for further evaluation were:

  - Peirce Island
  - PIT
  - PSNH/Sprague

- Treatment process selection was the second step in the evaluation of WWTF upgrades. Processes selection was focused on meeting secondary treatment and potential future TN effluent limits. Biological nutrient removal (BNR) processes can be used to meet both effluent treatment limits for secondary treatment and nutrient limits of 8. The selected secondary treatment technologies were:

  - MLE
  - IFFAS
  - SBR

- Potential WWTF alternatives were identified for each of the three WMP flow scenarios based on the WWTF site and process technology selections. WWTF alternative layouts for each scenario for the MLE, IFFAS, and SBR process technologies were created for the PI WWTF, PIT WWTF, and Sprague/PSNH sites. These layouts were used to identify space limitations and to develop capital costs.

- The build-out flow rates associated with the scenarios are presented in Table 5-5.

Table 5-5 Build-out Condition Flows in Year 2060 Associated with WMP Flow Scenarios

WWTF	Scenario 1	Scenario 2	Scenario 3
Peirce Island	7.7 MGD	4.1 MGD	0 MGD
PIT[1]	1.2 MGD	4.8 MGD	8.9 MGD

[1] PIT or Sprague/PSNH site for Scenario 3.

- Some treatment technologies are not feasible for all scenarios. Due to the limited amount of space on Peirce Island, the MLE and IFFAS have not been evaluated further for Scenarios 1 and 2. Only the SBR process is evaluated further for Scenarios 1 and 2.

- The evaluation of CSO abatement measures showed that the most suitable options for the South Mill Pond CSOs (010A/010B) were:

    - Scenario 1 – 2.9 MGal Off-line Storage Tank or additional sewer separation
    - Scenario 2 – Debottleneck Line between CSOs 010A/010B and Mechanic St. PS or additional sewer separation
    - Scenario 3 – Debottleneck Line between CSOs 010A/010B and Mechanic St. PS plus miscellaneous PI WWTF improvements or additional sewer separation

- Present worth estimates were used to compare alternatives for WWTF upgrades, collection system flow redirection, and CSO abatement measures. These estimates are summarized in Table 5-17. These costs are based on a TN of 8 mg/L. Initial indications are that a TN of 5 mg/L or lower will result in an additional 30 to 40 percent increase in capital cost as well as additional operation and maintenance costs. Preliminary estimates to complete Scenario 3 show the potential user rates exceeding 2.5% of the median household income.

Table 5-17 Present Worth Estimates for WMP Scenarios for a TN limit of 8 mg/L

	PI WWTF Scenario 1	PI/PIT WWTFs Scenario 2	PSNH Scenario 3			PIT Scenario 3		
Technology:	SBR	SBR	SBR	MLE	IFFAS	SBR	MLE	IFFAS
	M$	M$	M$	M$	M$	M$	M$	M$
WWTF	158[1]	238	146	145	153	145	141	144
Redirect/Shed	0	13	22	22	22	22	22	22
CSOs	27.2	4.2	14.4	14.4	14.4	14.4	14.4	14.4
Total	185.2	255.2	182.4	181.4	189.4	181.4	177.4	186.4

[1] WWTF option not feasible since available technologies cannot fit within the setback limits on PI.

- Overall, Scenario 3 presented the lowest present worth costs. Within Scenario 3 there are several options with similar estimated present worth costs. Expansion of the SBR system is preferred for several reasons outlined further in this TM including its potential for phasing.

- At this time, Scenario 3 using SBRs at the PIT WWTF is the preferred option of all scenarios developed and presented in this TM. It is recommended that a phased approach be considered under Scenario 3, pending the outcome of an affordability analysis that will be completed as part of TM 6 and any future piloting of emerging processes.

- The major area of concern that would influence a reevaluation of the preferred option is permitting for an 8.9 MGD outfall from the PIT WWTF. Permitting for an 8.9 MGD outfall at an affordable cost, in consideration of design and location as well as future effluent limits, are the most influential unknowns. The City is limited in its future decision-making ability until the permitting potential and likely future TN limits are known.

- Scenario 3 is also the preferred option of the City because it accomplishes moving sanitary wastewater treatment off of Peirce Island. This honors the reaffirmed intentions of City residents, and allows the City to remove an industrial use from the City's historic and residential downtown. Moving sanitary treatment off of Peirce Island also preserves and protects the remains of Fort Washington. The City believes that the section 106 process, for which US EPA would be the lead agency relative to the impact on the historic structures, will likely be controversial should the City choose to modify and expand the PI WWTF.

- Scenario 3 also allows for expansion if TN limits or other effluent limits change over time and also for potential future regional efforts for wastewater treatment and/or sludge reuse and/or disposal.

- Finally, Scenario 3 allows for a phased approach to design construction and implementation of secondary treatment. Such a phased approach not only makes the construction of a new facility potentially more affordable, but also has the benefit of delivering positive environmental impacts sooner rather than later as flow can be shed to the PIT WWTF. In addition, an expansion at PIT WWTF is not dependent on the viability of the emerging technology, BioMag™. If piloting of BioMag™ is successful the City may have opportunity at PIT WWTF to reduce its costs. If BioMag™ is not successful, the City can still proceed with construction using more traditional technologies.

5.1 PURPOSE

Technical Memorandum 5 (TM 5) is one of a series of interim deliverables prepared as part of the development of the Wastewater Master Plan (WMP) for the City of Portsmouth, New Hampshire (the City). TM 5 addresses the requirements of Task 5, the Alternatives Evaluation, identified in the WMP Work Plan, dated May 2007. Specifically, this TM describes the steps taken to meet the following requirements:

- Evaluate wastewater treatment alternatives available for the Peirce Island wastewater treatment facility (WWTF) to:
  1. Comply with the 2007 National Pollutant Discharge Elimination System (NPDES) permit requiring secondary treatment
  2. Provide biological nutrient removal (BNR) to reduce effluent nitrogen
- Evaluate combined sewer overflow (CSO) treatment and abatement alternatives for the three permitted CSO facilities within the City.

The structure of TM 5 is as follows:

- Overview of the City's WWTFs
- Overview of previous TMs submitted
- Regulatory framework under which TM 5 has been developed
- Wastewater treatment alternatives evaluation
- Long Term Control Plan (LTCP) Update
- WWTF site selection
- WWTF treatment technology selection
- WWTF cost evaluation
- CSO abatement evaluation
- Phased approach to plan implementation
- Findings and recommendations
- Next Steps

5.2 INTRODUCTION

5.2.1 Portsmouth WWTF Overview

The City owns and operates two WWTFs:

- The Peirce Island (PI) WWTF, rated at 4.8 million gallons per day (MGD), provides advanced-primary treatment for wastewater generated within the City, wastewater from the Town of Newcastle, and wastewater from portions of the Towns of Rye and Greenland.

- The Pease International Tradeport (PIT) WWTF, rated at 1.2 MGD, is a secondary treatment process utilizing the sequencing batch reactor (SBR) process, and provides BNR. It is located within the PIT on property leased to the City and only serves the PIT.

A map of the collection system showing the pump stations and WWTFs is provided for reference in Figure 4-1 in TM 4. (Note: All figures are located at the end of this TM.)

5.2.2 Previous Technical Memoranda

TM 1 through TM 4 have previously been prepared and submitted to EPA and the New Hampshire Department of Environmental Services (NH DES) in accordance with applicable regulatory orders and WMP Scope of Work. The content of these previous TM are summarized below.

- TM 1 defined the study parameters and developed project boundaries, including service area, potential WWTF sites, and the planning horizon and sustainability goals.
- TM 2 reviewed regulatory requirements, including permits, consent decrees, administrative orders, and LTCP guidance documents.
- TM 3 established the wastewater flows and organic loads which form the basis of WWTF evaluations described herein. The findings of TM 3 have been adjusted since its development as additional data has become available.
- TM 3 used maximum month flows to identify alternative WWTF capacity requirements. Maximum month values are appropriate for process design; however, it is standard practice to identify WWTF flow capacity based on average annual flow. For comparison purposes, WWTF alternatives in TM 5 are identified relative to an average annual flow of 8.9 MGD at build-out in Year 2060; final design will be based on Year 2030 max month flow of 13.0 MGD. The derivation of these values is presented later in this TM.
- TM 4 assessed compliance with regulatory requirements for CSO abatement and established baseline conditions using the collection system model as updated as part of the WMP process.

5.2.3 Regulatory Framework

In 2007 the EPA denied the renewal of the 301(h) waiver under which the PI WWTF was operating and issued a new NPDES permit requiring secondary treatment. Because the PI WWTF currently only provides advanced primary treatment, an Administrative Order (AO) was issued to set interim limits which the PI WWTF must meet until such time that a new secondary treatment process is constructed at the PI WWTF, or a new secondary treatment WWTF is constructed elsewhere.

In September 2009, the City and EPA entered into a Consent Decree (CD), which requires the WMP process be completed by September 2010 and that the recommendations of the WMP be implemented as expeditiously as practicable according to sound engineering and normal construction practices.

Anticipated Nutrient Limits

In addition to the issuance of the secondary treatment NPDES permit for the PI WWTF, it is anticipated that EPA will include a total nitrogen (TN) limit in future permits. In absence of scientifically-supported value a TN limit of 8 mg/L has been assumed for comparison purposes. The actual TN limit is expected to result from the final waste load allocations for the lower Piscataqua River. The final waste load allocations will take into account the evaluation of nutrient impacts to the Great Bay watershed recently completed by NH DES.

In keeping with engineering standards of practice, the TM 5 WWTF alternative evaluation also takes into consideration the potential to meet future NPDES permits requirements with TN limits lower than 8 which may be issued to the City.

On-going EPA and NH DES Communication

As stated above, the final waste load allocations for the lower Piscataqua River are pending, and have not been issued at the time of writing TM 5. Communications between the City, its consulting team, EPA and NH DES have been ongoing throughout the WMP process to ensure that all potential implications of the final waste load allocations are taken into account. While these communications have yielded several key considerations, a level of uncertainty and lack of guidance remains in the areas of anti-degradation, impacts to shell-fishing and other environmental concerns including the final determination of the TN limit.

5.3 WMP ALTERNATIVE EVALUATIONS

The WMP includes two major components, the WWTF upgrade and CSO abatement. The WWTF upgrade portion of the planning process involves two alternative evaluations, one focused on selection of potential WWTF sites and another focused on the selection of secondary treatment and nutrient removal processes. Preliminary screening of alternatives for WWTF site and treatment processes provides the basis of a more detailed evaluation of WWTF alternatives.

The CSO abatement alternative evaluation involves screening and selection of appropriate abatement controls and technologies. Although these WWTF upgrade and CSO abatement alternative evaluations are independent of one another, they are both dependent on many of the same considerations; namely, the potential flow scenarios described in Section 5.3.1.

5.3.1 WMP Scenarios

The WMP alternative evaluations centered around three basic scenarios for WWTF upgrade and CSO abatement planning. The scenarios were developed to focus on the primary goal of meeting secondary treatment and nutrient removal requirements for those wastewater flows currently being treated at the PI WWTF. The three scenarios are as follows:

1. Wastewater continues to be treated on Peirce Island.
2. Wastewater is split between the PI WWTF and the PIT WWTF
3. Wastewater is not treated on Peirce Island: all wastewater is redirected to PIT or a new site

The WWTF and conveyance modifications needed for implementation of these scenarios are summarized in Table 5-1. It should be noted that, due to its age and condition, the cost of refurbishing the Mechanic St. Pump Station (PS) is included under all three scenarios.

Table 5-1 Description of Wastewater Treatment Scenarios.

	Modifications			
Scenario	Peirce Island Site	PIT Site	New Site	Affected Pump Station
1	Upgrade. WWTF: Add secondary treatment and nitrogen removal as required	Nitrogen removal added, as required	N/A	Mechanic St. PS (refurbishment)
2	Upgrade WWTF and limited shedding of flow to PIT WWTF	Upgrade WWTF: Increase capacity and add nitrogen removal as required	N/A	*Existing:* Mechanic St. PS (refurbishment), Deer St. (partial), Gosling Rd., Lafayette Rd. and Atlantic Heights PSs *New:* Borthwick Ave. PS; and portion of Deer St. PS redirected to PIT
3	Remove all flow from Peirce Island	New WWTF to handle all current Peirce Island and PIT WWTF flows. This facility may be located at the current PIT WWTF or an alternative new site.		*Existing:* Mechanic St. PS (refurbishment), Deer St., Gosling Rd., Lafayette Rd., and Atlantic Heights PSs *New:* Dry Weather Mechanic St. PS; Peirce Island PS (for Newcastle and CSO process return flows) and new PIT PS required for the Sprague/PSNH site

Scenario 1 resembles existing conditions and involves virtually no changes to the City's current wastewater collection system infrastructure. The City would continue to own and operate two WWTFs, the existing PIT WWTF and an upgraded WWTF at Peirce Island.

The current pumping and gravity conveyance configuration would not require modification beyond those intended for CSO abatement.

Scenario 2 involves redirecting a portion of the current PI WWTF flow to the PIT WWTF by modifying select pump stations. A sufficient amount of flow would need to be diverted such that the PI WWTF could be upgraded to safely accommodate the secondary treatment and nitrogen removal processes required by potential new effluent discharge limits in future NPDES permits. The City would continue to own and operate the two WWTFs at Peirce Island and PIT, both of which will require upgrades. The Scenario 2 flow redirection would include the following changes:

- Redirection of the flow from Lafayette Rd., Gosling Rd. and Atlantic Heights PSs to the PIT WWTF.
- A new Borthwick Avenue PS to pump flows from that portion of the local sewer shed into the new Lafayette Rd. PS force main.
- Redirection of a portion of the Deer St. PS to the PIT WWTF – the Deer St. PS would be able to simultaneously pump to both the Mechanic St. PS and the PIT WWTF.

Scenario 3 involves the complete removal of sanitary flow from Peirce Island and the construction of a single WWTF at either the existing PIT WWTF site or a new site. For a new WWTF site, a new Pease PS would be required to convey the current PIT flow to the new WWTF at the alternative new site. In addition to the Scenario 2 flow redirection components, Scenario 3 would entail the following:

- Redirection of the entire Deer St. PS flow to the PIT WWTF or alternative new site.
- A new dry weather Mechanic St. PS to pump flows to the Deer St. PS.
- A new Peirce Island PS to pump flow from both the Town of Newcastle and any return flows associated with continued CSO treatment at the PI WWTF to the new dry weather Mechanic St. PS.

These scenarios form the basis of the both the WWTF and CSO abatement plans that are presented in subsequent sections of this TM. The full build-out flow rates associated with the scenarios are presented below under the WWTF Alternative Evaluation. Details of the collection system modifications and improvements (flow re-direction) required to implement these scenarios are presented later in the TM.

5.4 WASTEWATER TREATMENT ALTERNATIVE EVALUATIONS

Task 5 of the WMP process includes the recommendation of WWTF location(s) and secondary treatment and nitrogen removal processes. In order to make these recommendations, a preliminary site and technology screening process was conducted.

From the result of the screening process, the feasible sites and processes were combined into three WMP scenarios identified in Section 5.3.1.

5.4.1 WWTF Flows and Loads

Wastewater flows and loads were presented in TM 3, and provided projections for the years 2030 and 2060. In this TM, 2060 flows were used for sizing the wastewater treatment facilities, while 2030 flows were used for sizing the CSO abatement facilities. Using the 2060 projections for site technology screening is appropriate because sufficient room on the WWTF site must be provided for final build out, and the layout of the WWTF components, including tanks, piping and electrical conduit runs must be designed such that the required additional components meet year 2060 flows. However, it is important to note that actual design and construction of the WWTF should be based on 20 year projections, in keeping with standard engineering practices.

The year 2060 WWTF design basis for TM 5 is 8.9 MGD average daily flow, with the potential of 13.0 MGD as a maximum monthly flow. This maximum month flow occurred during a very wet period, and may not be indicative of true historic maximum month flows. Therefore, we have assumed that the continuation of sewer separation projects will reduce the peaking factor associated with the maximum month flow, and that the maximum month flow will remain unchanged from the historic value of 13.0 MGD through the year 2060. As presented in Table 5-2, wastewater flow in the City changes between current, Year 2030 and Year 2060. Because WWTF unit process sizing is based, in part, on maximum month flows, there would be no change in the WWTF size whether Year 2030 or Year 2060 flows are used as the maximum month flows do not change for either design period.

The derivation of the 8.9 MGD average daily flow values used for WWTF evaluations is presented in Table 5-2.

Table 5-2 Derivation of Average Daily Flow

Source	Current Plant Rating (MGD)	Increase through Year 2030 (MGD)	2030 Plant Rating (MGD)	Flow Increase through Year 2060 (MGD)	2060 Plant Rating (MGD)
PI WWTF	4.5	0.9	5.4	1.3	5.8
PIT WWTF	1.2	0.5	1.7	1.1	2.3
Regional	N/A	0.5	0.5	0.8	0.8
Combined	5.7	1.9	7.6	3.2	8.9

5.5 WASTEWATER TREATMENT SITE EVALUATION

The space available to construct a secondary treatment process at the PI WWTF site is limited. The existing PIT WWTF could be expanded and upgraded to treat full build-out flow, but this would require significant flow re-direction. Therefore, PIT and other sites in the Portsmouth area were evaluated.

To ensure that sufficient land area was identified, the "worst-case" treatment process technology from a required footprint standpoint was used to further screen those sites which survived the preliminary screening process.

The four-stage Bardenpho BNR wastewater treatment process was chosen as the "worst-case" treatment process technology from a required footprint standpoint. As will be discussed further in the BNR process overview presented later in this TM, the four-stage Bardenpho BNR process has been constructed to serve numerous cold weather municipalities and has a proven track record of meeting low TN limits. The results of TM 3 were used as a basis for sizing the Bardenpho process; "Worst-case" sizing assumed full build-out annual average flow conditions (8.9 MGD), a minimum wastewater temperature (10°C), and a TN limit of 3 mg/L. Through this process it was determined that a minimum of 10 acres would be required for all new sites.

5.5.1 Candidate WWTF Sites

Several candidate WWTF sites were identified in the City based on a 10-acre requirement for the "worst-case scenario" for BNR treatment. Table 5-3 lists these candidate sites.

Table 5-3 Candidate WWTF Sites

Name of site and description	Site Reference	Location
PI WWTF	A	PIT/Portsmouth
PIT WWTF	B	PIT/Portsmouth
Public Service of New Hampshire & Sprague storage site	C	Portsmouth
Granite State Minerals site(s)	D	Newington
Jones Avenue	E	Portsmouth
Portsmouth Naval Shipyard	F	Kittery, Maine
Borthwick Avenue	G	Portsmouth

The locations of each identified site are shown in Figure 5-1.

5.5.2 Preliminary Site Screening

Non-cost site evaluation criteria were developed to evaluate each of the above sites. Each criterion was ranked based on the following scoring system:

- Poor (P): -1 point
- Satisfactory (S): +1 point
- Exceptional (E): +2 points

The detailed criteria and rankings are provided in Appendix A.

Based on the results of the evaluation, the highest ranking alternative sites were as follows:

- PSNH
- Sprague
- PIT

The Peirce Island site will be evaluated further as a candidate site because it currently hosts one of the City's existing WWTF and offers potential capital cost savings from the re-use of existing facilities at the WWTF and minimizes changes to the current collection system flow direction. The PI WWTF also has an existing permitted outfall.

Brief descriptions of each candidate site are included in the following sections.

5.5.2.1 PI WWTF

As discussed previously, it is the City's desire to relocate the PI WWTF and reclaim Peirce Island for recreational purposes. If treatment at PI is deemed necessary, the City would prefer to keep all treatment within the existing fence line, however the fenced land area at the PI WWTF is less than 10 acres. Development outside the current WWTF area could provide upwards of 10 acres of buildable land, although existing shore land zoning setbacks may become an issue depending on the size of the facility required. Since the current primary WWTF is located on Peirce Island and the wastewater collection system infrastructure is constructed to convey all wastewater from the City (excluding PIT) to this site it was considered for evaluation.

The layout of a four-stage Bardenpho WWTF on Peirce Island is shown in Figure 5-2.

5.5.2.2 PIT WWTF

The PIT WWTF site has less than 10 acres of buildable area. However, land adjacent to the WWTF is available to meet the minimum land area required. Portions of the existing WWTF infrastructure could be used with a new WWTF. In addition, the PIT site lends itself to a phased construction approach, as detailed later in this TM.

The layout of a four-stage Bardenpho WWTF at PIT is shown in Figure 5-3.

5.5.2.3 PSNH/Sprague Site

PSNH and Sprague each own adjacent parcels near Shiller Station. The Sprague property is for sale. While not for sale, the PSNH property is closer to the Piscataqua River and more desirable for a WWTF layout. Both of these sites provide approximately 10 acres of area. The City contacted PSNH and Sprague regarding the availability of each site and discussed, at a preliminary level, purchasing and other potential options..

The layouts of a four-stage Bardenpho WWTF at the PSNH and Sprague sites are shown in Figures 5-4 and 5-5, respectively.

5.6 WASTEWATER TREATMENT PROCESS ALTERNATIVE EVALUATION

After the identification of potential sites, WWTF process selection was the next step in the WWTF upgrade alternative evaluations. Process selection was focused on meeting the secondary treatment requirement included in the new PI WWTF NPDES permit as well as potential future TN limits. Biological nutrient removal (BNR) process technologies, which use microbiological activity within the existing wastewater and process control to achieve reduction of TN through the nitrification and denitrification processes, have the ability to incorporate both of these items.

5.6.1 BNR Process Overview

The BNR process reduces the concentration of nutrients, specifically nitrogen and phosphorus, in WWTF effluent. The BNR process is a multistage treatment system consisting of anoxic and aerobic treatment tanks for nitrogen reduction; anaerobic and aerobic treatment tanks are utilized for phosphorus removal.

Both EPA and NH DES have stated that future NPDES permits issued to the City will include TN limits, but will not contain phosphorus limits. This is because in estuarine environments, nitrogen is the limiting nutrient. As such, phosphorus reduction has not been considered as part of the WWTF evaluations.

Effluent TN is reduced by transforming the chemical composition of nitrogen compounds in wastewater through biological nitrification and denitrification processes. Nitrogen exists in typical domestic wastewater as ammonia ($N\text{-}NH_3$) that enters the waste stream from human urine and other sources. BNR processes are designed to transform ammonia-nitrogen into compounds that are easily removed and are not harmful to receiving waters or the environment. To this extent, most BNR processes transform nitrogen compounds to elemental nitrogen (N_2) that is released as a gas under normal conditions to the atmosphere, which is made up of mostly nitrogen gas (78% by volume).

In order to form nitrogen gas, ammonia-nitrogen must be first oxidized to nitrate (nitrification) and then reduced (denitrification) biologically. Various species of bacteria involved in the nitrification process (nitrifiers) use dissolved oxygen (DO) provided by supplying air or pure oxygen through wastewater held in aeration tanks to oxidize ammonia-nitrogen to nitrite (NO_2-) and then nitrate (NO_3-). This process is shown by the following simplified chemical equations:

Nitrification: oxidation of ammonia-nitrogen to nitrate

1. $NH_3 + CO_2 + 1.5\ O_2 + \text{Nitrosomonas} \rightarrow NO_2^- + H_2O + H^+$
2. $NO_2^- + CO_2 + 0.5\ O_2 + \text{Nitrobacter} \rightarrow NO_3^-$

Overall nitrification reaction

1. $NH_3 + O_2 \rightarrow NO_2^- + 3H^+ + 2e^-$
2. $NO_2^- + H_2O \rightarrow NO_3^- + 2H^+ + 2e^-$

Once nitrates are formed, the wastewater is then moved to an anoxic tank to allow other bacteria (denitrifiers) to transform nitrates to nitrogen gas, which is then released to the atmosphere. Denitrifiers use the oxygen available in nitrate compounds to live since elemental oxygen (O_2) is not available.

Denitrification: reduction of nitrate to nitrogen gas

1. $2NO_3^- + 10e^- + 12H^+ + \text{Denitrifiers} \rightarrow N_2 + 6H_2O$

BNR process technologies are designed in different ways to provide the optimal conditions for bacteria to grow and to promote the nitrification and denitrification reactions to occur. The following sections summarize the BNR processes evaluated as part the WMP and describe how each process technology is configured to promote nitrification and denitrification reactions.

5.6.2 BNR Process Technologies

The City and the WMP Team identified BNR treatment technologies that are currently used in the US to reduce total nitrogen to meet effluent discharge permit limits in WWTFs.

As previous stated, the four-stage Bardenpho BNR process was used as a basis for site selection because it is a proven technology and requires a significant land area for implementation. Therefore, alternative BNR treatment technologies were considered to provide the same level of treatment, but at less capital, operation and maintenance cost.

The alternative technologies are listed in Table 5-4 and included traditional and emerging process technologies.

Table 5-4 Evaluated Secondary Treatment BNR Process Technologies for TN Reduction

Secondary Treatment Process Category	Process Technology
Activated Sludge/Suspended Growth	Oxidation ditch
	Multiple Stage Activated Sludge
	Sequencing Batch Reactor (SBR)
	Membrane Biological Reactor (MBR)
Fixed Growth/Hybrid	Biological Aerated Filter (BAF)
	Rotating Biological Contactors (RBC)
	Trickling Filter/Solids Contact (TF/SC)
	Integrated Fixed-Film Activated Sludge (IFAS)
	Moving Bed Biological Reactor
Emerging	BioMag
	Micro Media Filtration

5.6.2.1 Suspended Growth Processes

Suspended growth processes were originally developed to remove organic matter, expresses as carbonaceous biochemical oxygen demand (cBOD), from wastewater and expanded upon to remove nitrogen through BNR. The process is referred to as "activated sludge" because it promotes the growth of a mass of microorganisms, mostly bacteria, to consume organic matter in wastewater. The mass of microorganisms or activated sludge is recycled within the process by pumping and kept in suspension in wastewater to maintain growth and consumption of organic matter and nutrients by mixing. The mixture of circulated or returned activated sludge (RAS) with wastewater entering the process is referred to as "mixed liquor" and measured by the concentration of "mixed liquor suspended solids" (MLSS).

Oxygen is transferred to the mixed liquor in aeration basins to maintain a DO concentration of at least 2 mg/L. Because nitrifying bacteria grow slower than most heterotrophic bacteria in activated sludge, sludge retention time (SRT) within the aeration portion and within the entire process must be long enough so nitrifiers can thrive and are not removed or washed out of the system with settled solids. Bacteria growth rate is a function of temperature and must be considered during process design. Therefore, the additional treatment levels required to remove TN impact treatment tank size and the associated capital and operational costs.

Denitrification can be promoted by the addition of an anoxic zone before the aerobic zone (pre-anoxic) or after the aerobic zone (post-anoxic). A mixed liquor recycle is required for pre-anoxic zones to achieve high nitrate removal. For lower TN limits, an additional carbon source (typically methanol) may be required to promote growth of denitrifying bacteria in post-anoxic zones because of the low levels of organic matter remaining in wastewater leaving the aerobic zone.

Multiple Stage Activated Sludge

A multiple stage activated sludge system uses a conventional activated sludge system with additional aerobic and anoxic zones to enhance nitrogen removal and sludge settling characteristics. The configurations and complexity of additional zones varies by the type of multiple stage process, and can include multiple pre- and post-anoxic and aerobic zones. Pre-anoxic zones are added for denitrification of nitrates in RAS and to inactivate or restrict the growth of filamentous microorganisms that form in the aeration zone and impede settling performance of solids in downstream clarifiers. Post-aerobic zones are added to agitate denitrified mixed liquor to release entrained nitrogen gas that will also impede settling performance of solids.

Several types of multi-stage activated sludge processes are used in BNR systems in the U.S. and Europe. Each type differs in the number of stages; the nature and location of recycle streams; and process operation. These processes include: Modified Ludzak-Ettinger (MLE), Bardenpho, University of Capetown (UCT), Johannesburg (JHB), oxidation ditches with anoxic zones, and sequencing batch reactors (SBR).

Figures 5-6 and 5-7 show process flow schematics for the MLE and Bardenpho processes, respectively.

Oxidation Ditch

An oxidation ditch is an activated sludge process that occurs in an oval-shaped or "race track" reactor tank. Figure 5-8 shows a process flow diagram for an oxidation ditch system. Influent wastewater and returned sludge are introduced into a pre-anoxic zone and the effluent from the anoxic zone flows to an aeration zone or oxidation ditch. Nitrification occurs in the aerobic zone while nitrogen gases formed during denitrification in the pre-anoxic zone are agitated and released to the atmosphere.

Aeration and mixing devices in the oxidation ditch provide unidirectional flow through the oval-shaped reactor and keep MLSS in suspension and the activated sludge microorganisms in contact with incoming wastewater. Horizontally or vertically mounted aerators (brush rotors, disc aerators, draft tube aerators, or fine bubble diffusers) provide circulation, oxygen transfer, and aeration in the ditch. Effluent from the aerobic reactor containing a high nitrate concentration flows to a clarifier where nitrate-rich RAS that settles is recycled to the pre-anoxic zone for denitrification.

Sequencing Batch Reactor (SBR)

An SBR is a multi-stage activated sludge process in which all stages take place in a single reactor or tank in a batch process. These stages include cBOD reduction, nitrification, denitrification and clarification and are represented by different "modes" during operation of the SBR. These modes are shown in Figure 5-9.

The SBR process typically requires a significantly smaller footprint than other multi-stage activated sludge processes because it uses a single reactor tank and does not need separate clarifiers. SBRs are currently used at over 100 New England WWTFs and over 1,000 WWTFs worldwide.

Membrane Bioreactor (MBR)
The MBR is an activated sludge process in which a membrane filter (ultrafilter or microfilter) is used in place of a clarifier for solid-liquid separation downstream of the aerobic zone. Similar to all multi-stage activated sludge systems for BNR, denitrification in an MBR requires a pre-anoxic zone with mixed liquor recycle upstream of the membrane reactor. Figure 5-10 shows a process flow diagram for a typical MBR system.

MLSS concentrations in MBR systems are generally five times greater than in conventional activated sludge systems because of the greater solid-liquid separation capability of membrane filtration versus gravity settling. Fine screening is necessary and crucial to prevent clogging of membranes; typical screen sizes for MBRs range from 1 to 3 mm spacing.

5.6.2.2 Fixed Growth/Hybrid Processes
Similar to multiple-stage activated sludge BNR systems, fixed growth BNR systems were originally developed to remove organic matter in the form of cBOD and have been modified to remove nutrients over the years. Hybrid systems are one example of these modifications. In contrast to suspended growth processes, the microbial mass in a fixed film and hybrid process is grown as a biofilm slime layer on support media through contact with wastewater. Commonly used support media include stone, wood, and plastic. Fixed growth processes are also referred to as "fixed film" or "attached growth" systems. Conventional fixed film processes used for BNR include trickling filters and rotating biological contactors (RBCs).

Like activated sludge BNR systems, conventional fixed film processes were modified for BNR by adding separate stages for nitrification and denitrification. For fixed-film processes, nitrification only occurs with very low organic loading rates because nitrifying bacteria must compete with heterotrophic bacteria that have an abundant food source: cBOD. In some cases, downstream nitrifying trickling filters are added to reach the level of nitrification required to meet nitrogen limits. In response to footprint concerns and nutrient requirements, some hybrid processes were developed that allowed higher solids loading and enhanced nitrification within activated sludge systems by providing carrier media on which microorganisms could grow and form a biofilm. Both fixed-growth and hybrid systems require a downstream clarifier for solids removal. Hybrid processes also need downstream denitrification processes, such as a denitrifying filter.

Biological Aerated Filters (BAF)
The BAF system is a fixed-film process where primary effluent flows up through a filter bed packed with media. The submerged media provides growth sites for fixed-film microbes to thrive and develop biofilms which provide secondary treatment, nitrification,

and denitrification of incoming wastewater. The filter bed consists of multiple tanks or cells filled with plastic or sand media. Fine screening (< 2mm) is required upstream of the BAF to prevent fouling of the filter bed and media. However, secondary clarifiers are not required because of the backwashing system that removes fixed-film "slough" from the system periodically. Figure 5-11 shows a typical process flow diagram for a typical BAF process.

The BAF system has limited use in New England, but has more operating installations worldwide. Locations of BAF installations that exist in New England at the time of this TM include Southington and Chesire, CT, and West Warwick, RI.

The leading manufacturers of BAF systems at this time include Kruger Biostyr, and IDI Biofor.

Trickling Filter/Solids Contact (TF/SC)

Trickling filters (TF) are the most common fixed-growth process. In a trickling filter, wastewater is sprayed over a tower packed with highly permeable media and allowed to trickle down through the media by gravity, also exposing the wastewater to air; thus, the microbial mass and media are static while the wastewater (and air) is mobile through the system. During startup of a trickling filter, the biofilm must be grown through contact with wastewater before the process can be operated at steady state. Maintaining this biofilm is the key to the performance of the trickling filter, and process upsets can occur when this biofilm is detached or "sloughed off" from the media.

However, trickling filters alone often cannot fully nitrify ammonia-nitrogen in wastewater. High BOD loading rates and relatively short residence time in trickling filters do not allow nitrifying bacteria to grow. Also, solids produced from the sloughing-off of biofilm in a TF create pin floc with poor settling characteristics in a clarifier. The trickling filter/solids contact (TF/SC) process adds a solids contact tank downstream of TFs to flocculate and improve the settleability of TF solids. Figure 5-12 shows a process flow diagram for a typical TF/SC process. The solids contact (SC) tank has relatively short solids retention time (1.5 to 2 days) and hydraulic retention time (30 to 60 minutes) and does not provide enough time for nitrifying bacteria to grow.

For BNR purposes, a separate nitrifying trickling filter can be added downstream of the SC tank to nitrify ammonia-nitrogen and a denitrification process can be added downstream for total nitrogen removal. Figure 5-13 shows a TF/SC process with nitrifying trickling filters and denitrification filters designed by Brown and Caldwell for the Littleton/Englewood WWTF in Colorado. Essentially, the TF/SC process with NTFs and denitrification are a separated version of the multi-stage activated sludge process, with fixed-growth used in lieu of suspended growth. Fixed-growth processes typically require significantly less energy than suspended growth processes because of their smaller blower and mixing needs.

In place of a solids contact tank and a separate nitrifying trickling filter, some TF systems designed for BNR include a downstream activated sludge process and are referred to as TF/AS. The activated sludge process is designed with higher SRTs to allow for nitrification and can include a downstream denitrification process to meet total nitrogen requirements.

Rotating Biological Contactors (RBC)

An RBC is designed using the same concept as a trickling filter, but the biofilm support media is mobile and the wastewater is static. Discs containing media are rotated along a shaft through a trough of wastewater, submerging the media and biofilm in wastewater and then exposing them to air for oxygen transfer. Multiple stages can be used for cBOD reduction and nitrification, with different rotational speeds, number of RBC units, and hydraulic retention times used for each stage. RBC effluent is typically sent to a clarifier for solids removal and a denitrification process is needed downstream for nitrate reduction to meet total nitrogen requirements. Figure 5-14 is a typical process flow diagram for an RBC process with downstream denitrification.

Integrated Fixed Film Activated Sludge (IFFAS) & Moving Bed Bioreactor (MBBR)

The IFFAS and MBBR systems form hybrid processes that increase loading rate and enhance nitrification in activated sludge systems, especially in colder climates, by using fixed-growth on carrier media. These systems are used primarily to lower the footprint needed for nitrification and denitrification at land-constrained sites. The carrier media is suspended and mixed in the aeration basins of an activated sludge process and provide high surface area growth sites for microorganisms and be maintained as a biofilm. The media can be placed in a multi-stage activated sludge process, as shown in Figures 5-6 thru 5-8, to provide fixed-growth treatment within suspended growth environments. Figure 5-15 shows the typical size and type of media used in an IFFAS and MBBR system.

Because IFFAS and MBBR are primarily a modification to an existing activated sludge process, the process flow for the hybrid system formed will resemble the process it is used with for BNR such as MLE, Bardenpho, etc. Adjustments include additional mixing energy to keep media in suspension and internal mixed liquor and recycle stream pumping modifications for IFFAS processes. A MBBR system differs from an IFFAS process because it does not include sludge recycle and only the surplus biomass has to be separated. Surplus biomass sloughs off the media and is carried out of the process with treated effluent. Because no sludge is returned, the growth and maintenance of biomass within the MBBR system is the key to its performance. The MBBR process can be modified into an IFFAS system. IFFAS and MBBR systems both require downstream solids removal from effluent wastewater using clarifiers or other physical separation processes. Dissolved air flotation (DAF) is often used after IFFAS and MBBR processes because experience shows that a highly loaded IFFAS or MBBR bioreactor may result in poorly settleable but easily floatable sludge, and also because it is a small footprint separation technique.

5.6.2.3 Emerging Technologies

BioMag™

The BioMag™ system is an emerging biological treatment technology that incorporates magnetite ballast into biological floc to increase specific gravity and improve settling of the biological floc as compared to traditional suspended growth/activated sludge processes. The magnetite ballast is recovered and reused using shearing and magnetic separation equipment. This equipment includes an in-line shear mixer and magnetite recovery drum. The system is patented and produced by a single manufacturer, Cambridge Water Technologies (CWT).

Initially, the system was designed to allow significantly higher solids loading and MLSS concentrations in a conventional activated sludge system within the same process footprint. Some recent pilot testing has indicated potential enhancements to nitrogen removal, and this is being confirmed by the manufacturer through a variety of full scale operational tests throughout the country. A process flow diagram of the BioMag™ system is shown in Figure 5-16.

It is the understanding of the WMP team that the BioMag™ system is most beneficial when integrated with an SBR system because of potential settling issues with magnetite in return flow lines for activated sludge systems.

MicroMedia Filtration and CleanScreen System

The MicroMedia Filtration (MMF) System is a new system that combines physical separation and biological processes into a packaged system. The system includes influent screening to remove large particulate solids from raw wastewater, followed by a sand filtration vessel and a biological treatment vessel.

The system has been used on a limited basis for treatment of small flows from 0.1 to 2.4 MGD for pilot scale demonstration and for full scale installation. A pilot-scale demonstration facility has been operating in Deersville, NH since September, 2008 treating approximately 0.06 MGD. The largest installation of the MMF system is scheduled to be fully operational at the City of Adelanto, CA WWTP (2.4 MGD).

Limited information and performance data for the MMF system has been provided by local representatives Green Power Management in Newmarket, NH. The system's performance for nitrogen removal was unclear at the time of this TM.

5.6.2.4 BNR Process Technology Screening Criteria

The City and WMP project team developed evaluation criteria to perform a preliminary screening of BNR process technologies in order to focus the more detailed WWTF layouts and cost analysis efforts on realistic treatment alternatives for the City.

Preliminary screening of treatment technologies utilized selected criteria based on the selected WWTF sites on Pierce Island, PIT, and at PSNH/Sprague. Technologies not meeting any of these criteria were not further evaluated. Criteria were based on permit requirements of 30 mg/L, 30 mg/L, and 8 mg/L for BOD, TSS, and TN, respectively. These criteria were presented at the Secondary Treatment Technology Workshop held on June 11, 2008. Additional criteria have been developed to evaluate:

- The ability of the technology to meet TN limits as low as 3 mg/L.
- The ability to provide for advanced biosolids handling
- Operability, resiliency and energy use.
- Ease of upgrading to more stringent limits and/or higher flows and loads.

Non-cost evaluation criteria were developed to evaluate each of the secondary treatment technologies. Each criterion was ranked based on the following scoring system:

- Poor (P): -1 point
- Satisfactory (S): +1 point
- Exceptional (E): +2 points

The detailed criteria and ranking results are provided in Appendix B.

5.6.2.5 BNR Process Technology Screening Results

The highest ranking secondary treatment technologies were as follows with final rank shown in parenthesis:

- IFAS (1)
- SBR (1)
- MLE (2)

These process technologies were evaluated further through preliminary modeling and process sizing. The assumptions and methodology used for preliminary modeling are described in Appendix C. For the purposes of this report, BioWin modeling considered the SBR process similar to the Bardenpho process.

Although BioMag™ did not rank as high as the MLE, IFAS, or SBR processes, it presented a potential method for significantly reducing process tank size and capital costs when used in conjunction with SBR. Because of the reduction in required capacity, an integrated SBR- BioMag™ process has the potential to make some WMP flow scenarios feasible that are not feasible due to required footprint and available land space. According to the vendor, integration of the BioMag™ system to a conventional SBR process could provide a 75 to 100 percent increase in process capacity. The increased capacity and reduced footprint gained from an integrated SBR-BioMag™ process could make

Scenario 1 a feasible option and reduce capital and operation and maintenance (O&M) costs for Scenarios 2 and 3.

While a SBR- BioMag™ system shows promise, the WMP team recognizes that the BioMag™ system is an emerging technology and has not yet been applied full scale to an SBR facility for BNR at flows similar to future wastewater flows that the City is facing. Therefore, the BioMag™ system may be evaluated further and considered for pilot testing at the existing PIT WWTF in the future.

5.7 WASTEWATER TREATMENT FACILITY ALTERNATIVES EVALUATION

Based on the site and technology selections presented above, potential WWTF alternatives were identified for each of the three WMP flow scenarios. WWTF alternative layouts for the MLE, SBR and IFFAS treatment technologies have been created for the PI WWTF, PIT WWTF, and Sprague/PSNH sites. These layouts were utilized to identify space requirements and to develop capital costs.

5.7.1 Wastewater Treatment Scenarios

The build-out flow rates associated with the scenarios are presented in Table 5-5.

Table 5-5 Flow Rates for Year 2060 Build-out Conditions for WMP Flow Scenarios

WWTF	Scenario 1	Scenario 2	Scenario 3
Peirce Island	7.7 MGD	4.1 MGD	0 MGD
PIT[1]	1.2 MGD	4.8 MGD	8.9 MGD

[1] PIT or Sprague/PSNH site for Scenario 3.

The WMP Team developed preliminary layouts showing selected secondary treatment technologies sized to treat different potential effluent TN limits of 8, 5, and 3 mg/L for the different scenarios. These layouts were used to evaluate the feasibility of constructing the necessary WWTF modifications under each flow scenarios and potential TN limits given the limits to available land space at each WWTF site. Layouts also depict additional unit processes and equipment required for each WWTF alternative.

5.7.1.1 Unit Processes and Equipment

All treatment scenarios include the additional necessary infrastructure to support wastewater treatment. The additional requirements include the major unit processes presented in Table 5-6.

Table 5-6 Major Unit Processes Required for WWTF Alternatives

	PI WWTF	PIT WWTF	PSNH/Sprague
Headworks	New	New	New
Primary Clarifiers[1]	Reuse existing tanks, replace drives	New	New
BNR Process	New	Expand existing/New	New
Secondary Clarifiers[2]	N/A	N/A	New
Denitrification Filters[3]	New	New	New
Biosolids Handling[4]	New	New	New
Disinfection	New	New	New

[1] Not required for IFFAS
[2] Not required for SBRs
[3] For TN 3 and TN 5
[4] Includes sludge holding tank

New equipment and chemical storage buildings, flow diversion structures, pump systems, etc, are also included, as required. For the PI WWTF, existing facilities, such as laboratory and office areas are expanded and rehabilitated.

5.7.1.2 Limitations and Assumptions

Some treatment technologies were not feasible for all scenarios. The MLE and IFAS process technologies require large footprints and secondary clarifiers. Due to the limited amount of space on Piece Island, MLE and IFFAS were deemed inappropriate for further analysis in Scenarios 1 and 2 because they both involve treatment on the island. The footprint for an SBR facility requires less area since secondary clarifiers are not required; therefore, the technology has the potential to be utilized on Peirce Island.

Should the City have to modify and expand the existing PI WWTF, EPA would be the lead agency to participate in the Section 106 process relative to the impacts of the expanded WWTF on the existing historic structures on Peirce Island, such as at Fort Washington. Keeping sanitary treatment at Peirce Island would also likely impact shoreland protection setbacks from expansion necessitated by regulatory changes and new effluent limits in the future if not immediately.

If construction is restricted to within the existing fence line at the PI WWTF, the capacity of a new SBR process is limited to approximately 2.2 MGD, as show in Figure 5-17. This would require the PIT WWTF to treat 6.7 MGD at build out, and would require significant modifications to the collection system. It is not logical to reroute such a high percentage of the flow to PIT because the City would need to expand and operate both the PIT and PI WWTFs and make significant changes to the collection system and pump stations. If the City were going to put in the required effort to reroute significant flow to PIT the more effective measure would be to reroute all the flow and operate only one

WWTF. For this reason, the option of constructing an upgrade to the PI WWTF within the fence line has not been considered further. Instead construction options outside the fence line have been considered for Scenarios 1 and 2.

Because only the SBR process can fit on the PI WWTF site (outside the fence line) within the required setbacks, and because the SBR process already exists at the PIT WWTF, Scenarios 1 and 2 only include the SBR technology.

As discussed previously, each flow scenario was based on a TN limit of 8 mg/L. However, because the final decision in regards to TN limits throughout the watershed have yet to be determined, each scenario also considered a TN limit as low as 3 mg/L. A TN limit of 3 mg/L is considered the limit of technology for warm weather climates and it may not be possible to be consistently met in cold weather climates, such as Portsmouth.

With the exception of the SBR process, the BNR tank volumes required to meet a TN limit of 8, 5, or 3 mg/L are identical. The SBR process benefits from simultaneous nitrification and denitrification in a single tank, and requires longer detention times and thus larger tank volumes, to meet lower TN limits. For all processes, the BNR tank volumes required to meet a TN limit of either 5 or 3 mg/L are identical. However, the quantity of additional carbon (i.e., methanol) needed to meet a limit of 3 mg/L can be significantly greater than that required for a limit of 5 mg/L. For both TN limits of 5 and 3 mg/L, a tertiary denitrification filter has been included to meet these lower limits. The capital and operational costs associated with achieving a TN limit of 8 mg/L compared to a 5 or 3 mg/L goal are significant and could add an additional 30 to 40% in capital costs to a BNR facility.

In this TM, the evaluation of BNR treatment processes focus around a TN of 8 mg/L and, as a result, do not include costs for a tertiary denitrification filter or the use of additional carbon sources. However, space allowances for these facilities have been provided should they become necessary in the future.

5.7.1.3 Scenario 1

Scenario 1 presents the most significant impact to the PI WWTF and the smallest impact to the City's existing collection system infrastructure. The PI WWTF would be upgraded from a primary treatment facility to meet future TN limits under the full build-out flow condition and maintain expandability to meet potentially more stringent TN limits in the future. The PIT WWTF would also be upgraded to include nitrogen removal to meet future TN limits. Under Scenario 1, the City would own and operate two advanced secondary WWTFs, each with BNR limits.

At this time, options that preserve a WWTF on Peirce Island are not the preferred alternative for the City for several reasons. Removing the existing sanitary WWTF from

Peirce Island honors the intent of City residents as expressed at the Public Hearing held on September 7, 2006, to move sanitary treatment off of Peirce Island if feasible. That intent was recently reaffirmed by the Portsmouth City Council during its consideration of the alternatives presented in this TM.

As mentioned, EPA would be the lead agency to participate in the Section 106 process relative to the impacts of the expanded WWTF on the existing historic structures on Peirce Island, such as at Fort Washington, should the City have to modify and expand the existing PI WWTF.

Figure 5-18 shows the PI WWTF layout required under Scenario 1. As shown in this figure, the land space required at the PI WWTF for Scenario 1 using a conventional SBR process was beyond the available footprint due to coastal setback restrictions. This shows that implementing Scenario 1 is not feasible using conventional SBRs and, as a result, will not be evaluated further in this TM as a viable option for the City.

5.7.1.4 Scenario 2

Scenario 2 presents the most widespread impact to overall wastewater conveyance and treatment infrastructure in the City.

The PI WWTF would receive flow from the following PSs:

- Mechanic St. (excluding Lafayette Rd. PS)
- Deer St. (partial)

The PIT WWTF would receive flow from the following PSs:

- Gosling Rd.
- Lafayette Rd. (including flow from a potential new pump station at Borthwick Ave.)
- Atlantic Heights
- Deer St. (partial)

The Deer St. PS would be modified to pump in two directions to provide flow to both the PI WWTF and PIT WWTF.

The PI WWTF would be upgraded to provide BNR with the SBR process at a flow of 4.1 MGD. As shown in Figures 5-19 (8 mg/L TN), and 5-20 (3 mg/L TN) this facility would be sized to meet a TN limit of 3 mg/L and can fit within the setback limits, albeit outside the existing fence line.

The PIT WWTF would be upgraded in capacity to provide treatment at a flow of 4.8 MGD by expanding the existing SBR process and constructing additional infrastructure to support the higher flows. The layout for this facility is shown on Figures 5-21 and 5-22 for TN limits of 8 mg/L and 3 mg/L, respectively.

With Scenario 2, the City would own and operate two treatment facilities with BNR and must comply with two NPDES permits. Although this scenario has drawbacks, implementing modifications defined by Scenario 2 may be necessary given the outfall and site limitations discussed previously.

5.7.1.5 Scenario 3

Scenario 3 presents the most impact to the existing wastewater conveyance system in the City because all flow must be re-directed to either the PIT WWTF or a new WWTF at the PSNH/Sprague site. Therefore, Scenario 3 also presents the most impact to the PIT WWTF and the highest level of new construction if a new WWTF site is selected.

The PIT or new PSNH/Sprague WWTF would receive all of the City's wastewater flow from the following PSs:

- Mechanic St. (including flow from Lafayette Rd. PS)
- Deer St.
- Atlantic Heights
- Gosling Rd.

If selected, the PIT WWTF would be upgraded to meet future TN limits for the full build-out flow condition and maintain expandability to meet potentially more stringent TN limits in the future. If the PSNH/Sprague site is selected, then the City would construct an entirely new WWTF to meet future TN limits for the full build-out flow condition and maintain expandability to meet potentially more stringent TN limits in the future. In either case, flow must be re-directed from the PI WWTF to either the upgraded PIT WWTF or a new WWTF at the PSNH/Sprague site.

The existing PI WWTF would be converted to treat wet-weather flow. Under Scenario 3, the City would own and operate one advanced secondary WWTF with BNR under a single NPDES permit and one wet weather or CSO-only treatment facility under a modified version of the existing NPDES permit for the PI WWTF or under a single permit defining limits at all outfalls, including CSOs.

Figures 5-23 through 5-34 show the WWTF layouts required under Scenario 3 for TN limits of 8 and 3 mg/L for the MLE, SBR and IFFAS processes.

5.7.2 Outfall Impacts

With Scenarios 2 and 3, the existing PIT outfall would need to be replaced to allow for the higher flow rate. This will require permitting, including an anti-degradation analysis. It may also require approval from the State of Maine Department of Environmental Protection (ME DEP). A letter from Spinney Creek Shellfish to the City documenting their input on the impacts of the PIT WWTF or a new outfall to their shellfish beds is included in Appendix D.

If the existing PIT WWTF outfall cannot be permitted, then a new outfall location, possibly near CSO 13 at the Deer Street PS, will be required. This will also require new pumping and infrastructure to convey the flow the new outfall location. The cost of the new outfall would be similar to that required to replace the existing PIT outfall. However, the cost to construct the pumping and conveyance system to bring effluent from the PIT WWTF to the Deer St PS area, assuming it is constructed concurrently with a new force main from the Deer St PS to the PIT WWTF, would add an estimated $5,800,000 to the WWTF capital cost presented below.

For cost comparison purposes, Scenario 1 presents the lowest potential outfall costs because it allows for re-use of the existing outfalls at the PI and PIT WWTFs for build-out flows similar to the current permitted flow and capacity at each existing outfall. Scenario 3 presents the highest outfall costs because it relies on using the existing PIT WWTF outfall for build-out flows and requires further anti-degradation analysis at costs to the City.

5.7.3 WWTF Costs to Implement Flow Scenarios

BNR process technology sizes needed to meet potential future TN limits were determined by BioWin™ modeling. The modeling results and BNR process sizes are shown in Appendix C. Based on these results, the capital, operation and maintenance costs for the treatment technologies / scenarios presented previously have been developed. Life cycle costs have also been developed based on a discount rate of 5% and a planning period of 20 years.

It must be noted that the modeling has not been calibrated, since a wastewater characterization study has yet to be performed. Once this study is complete and the model is calibrated, the tanks sizes and supplemental carbon requirements will be refined, thus allowing the life cycle costs to also be refined.

5.7.3.1 Scenario 1

The MLE, SBR and IFFAS WWTF alternatives which can treat 7.7 MGD do not fit within the required setbacks for Peirce Island without impacting the Fort Washington historical area and have not been considered further.

5.7.3.2 Scenario 2

Table 5-7 shows a summary of the capital and O&M costs associated with modifying the PI and PIT WWTFs under Scenario 2 and operating and maintaining these modified WWTFs over a 20-year period. The detailed spreadsheets used to develop these costs are included in Appendix E.

Table 5-7 Scenario 2 Cost Estimates

TN Limit, mg/L	8		
Technology	SBR		
	Capital Costs, M$	O&M Costs, M$/year	Present Worth, M$
PI/PIT WWTF	131	8.5	238
TN Limit	5		
Technology	SBR		
	Capital Costs, $M	O&M Costs, $/year	Present Worth, $M
PI/PIT WWTF	153	8.9	264
TN Limit	3		
Technology	SBR		
	Capital Costs, M$	O&M Costs, $/year	Present Worth, $
PI/PIT WWTF	153	9.0	266

5.7.3.3 Scenario 3

Table 5-8 shows a summary of the capital and O&M costs associated with modifying the PIT WWTF or constructing a new WWTF facility under Scenario 3 and operating and maintaining these WWTFs over a 20-year period. The detailed spreadsheets used to develop these costs are included in Appendix E.

Table 5-8 Scenario 3 Cost Estimates

TN Limit, mg/L	8								
Technology	MLE			IFFAS			SBR		
	Capital Costs, M$	O&M Costs, $/year	Present Worth, $	Capital Costs, M$	O&M Costs, $/year	Present Worth, $	Capital Costs, M$	O&M Costs, $/year	Present Worth, $
PIT WWTF	70	5.7	141	78	5.7	150	70	5.6	141
PSNH/ Sprague[1]	74	5.7	145	81	5.7	153	72	5.6	142
TN Limit	5								
Technology	MLE			IFFAS			SBR		
	Capital Costs, M$	O&M Costs, $/year	Present Worth, $	Capital Costs, M$	O&M Costs, $/year	Present Worth, $	Capital Costs, M$	O&M Costs, $/year	Present Worth, $
PIT WWTF	91	6.1	167	95	6.1	171	92	6.0	168
PSNH/ Sprague[1]	95	6.1	171	98	6.1	174	95	6.0	171
TN Limit	3								
Technology	MLE			IFFAS			SBR		
	Capital Costs, M$	O&M Costs, $/year	Present Worth, $	Capital Costs, M$	O&M Costs, $/year	Present Worth, $	Capital Costs, M$	O&M Costs, $/year	Present Worth, $
PIT WWTF	92	6.2	169	95	6.2	172	93	6.1	170
PSNH/ Sprague[1]	95	6.2	172	98	6.2	176	96	6.1	173

Present worth costs for Scenario 3 are significantly less then for Scenario 2. The lowest present worth option is either an MLE or SBR system at the PIT site. Because the costs of these two options are nearly identical, the expansion of the SBR system is considered more favorable due to the potential for phasing which will be discussed in greater detail later in this TM.

5.7.4 Advantages and Disadvantages of WMP Scenarios

Table 5-9 presents a summary of the advantages and disadvantages of each of the Scenarios presented.

Table 5-9 Summary of the Advantages and Disadvantages for WMP Scenarios

Scenario 1	
Advantages	Disadvantages
Would not require re-direction of flows	May not be feasible unless emerging technology is proven to be effective and implemented at PI WWTF.
Allows re-use of existing facilities at PI and PIT WWTFs	Requires significant additional land use outside of existing WWTF fence line
Current outfall at PI WWTF has capacity for build-out conditions and location at PI WWTF could be permitted easier than other locations such as PIT WWTF	Prevents removal of WWTF on Peirce Island and recapture of Peirce Island for recreational/other City use
	Truck traffic for biosolids hauling, chemical delivery, etc. increases in surrounding area of Peirce Island WWTF
	Requires City to own and operate two advanced secondary/BNR treatment facilities
	Requires the reuse of aging infrastructure at PI WWTF.
Scenario 2	
Advantages	Disadvantages
Allows re-use of existing facilities and outfall at Peirce Island and PIT WWTFs	Highest capital cost and present worth option
	Requires re-direction/flow shedding to divert flow to the PIT WWTF
	Requires automated flow control structure at Deer St. PS to divert flow between PI and PIT WWTFs
	Requires significant additional land use outside of existing WWTF fence line
	Prevents removal of WWTF on Peirce Island/recapture of Peirce Island for recreational/other City use
	Truck traffic for biosolids hauling, chemical delivery, etc. increases in surrounding area of PI WWTF
	Requires City to own and operate two advanced secondary/BNR treatment facilities
	Requires expansion of PIT WWTF beyond existing fence line and into adjacent ball field
	May requires upgrade to Newington WWTF effluent discharge system via new effluent pumping station
	Increased flow discharged through existing outfall at PIT WWTF, anti-degradation analysis and comprehensive modeling will be required for permitting

Table 5-9 Summary of the Advantages and Disadvantages for WMP Scenarios (con't.)

Scenario 3	
Advantages	Disadvantages
Allows potential re-use of existing facilities and outfall at PIT WWTFs	Highest impact to existing collection system and pump station infrastructure.
Allows PI WWTF to be re-used as "PLUS" project for wet weather treatment	If the Sprague/PSNH site is utilized, the land must be purchased
Removes sanitary WWTF from Peirce Island and recapture of Peirce Island for recreational/other City use	Requires expansion of PIT WWTF beyond existing fence line and into adjacent ball field
Lowest capital cost and present worth	Feasibility of new WWTF site depends on re-use of PIT WWTF outfall; potentially requires new outfall structure at CSO 13/Deer St.
	Requires upgrade to Newington WWTF effluent discharge system via new effluent pumping station
	Increased flow discharged through existing outfall at PIT WWTF: new outfall may be necessary and anti-degradation analysis and comprehensive modeling will be required for permitting

5.8 REQUIRED COLLECTION SYSTEM MODIFICATIONS

5.8.1 Scenario 1

The existing PI WWTF site is being considered for expansion to meet the regulatory requirements of the current and future potential NPDES Permits. Because all wastewater flow is currently conveyed to Peirce Island, there are no changes needed to the existing collection and conveyance systems other than those ongoing projects that are necessary to upgrade the City's existing infrastructure due to age or condition. This option is considered as Scenario 1 and is shown schematically on Figure 5-35.

Continued implementation of the ongoing LTCP will reduce wet weather flows from the combined sewer areas as discussed in TM 4. Additionally, the City will continue to monitor and address wet weather flows from the outlying separated sewer system areas and identify and remove extraneous flows that are found to be cost-effective. The existing collection system and pumping stations have been evaluated in previous wastewater planning studies and were not evaluated in detail as part of this technical memorandum.

5.8.1.1 Sewer Pumping Stations and Force Mains

The Deer St. and Mechanic St. PSs have recently been upgraded as part of the 2005 LTCP. Both stations convey the majority of wastewater and combined sewer flows from the City, ultimately to Peirce Island for treatment. The Deer St. PS is capable of pumping 12.0 MGD while the Mechanic St. PS was designed to convey 22.0 MGD to the existing PI WWTF. The Mechanic St. PS will require refurbishment to address pump reliability and age. A complete upgrade of the Mechanic St. PS will be necessary within the implementation period of the WMP.

No additional modifications are required under this scenario.

5.8.1.2 Gravity Sewer Lines

There are minor modifications to the existing gravity sewers required under Scenario 1. The ongoing LTCP projects will continue to proceed based on the CD schedule. Improvements required as a result of system age were not identified within this TM and may occur. Debottlenecking of the Parrott Avenue interceptor would be necessary to convey additional wet weather flows to the Mechanic Street PS. Minor debottlenecking of the sewer lines along Marcy St. will also be required under Scenario 1.

5.8.2 Scenario 2

As previously presented in this TM, Scenario 2 includes upgrades to the PI WWTF. This upgrade will be necessary to meet current and future anticipated regulatory requirements. The scenario also includes shedding of wastewater flow from outlying PS sewer-sheds to an expanded and upgraded PIT WWTF. This section discusses the modifications necessary within the collection and conveyance system necessary to accomplish this scenario. See Figure 5-36 for a schematic of this scenario.

As previously discussed, since all wastewater is currently conveyed to the PI WWTF through the Mechanic Street PS, there are no changes necessary for the Mechanic St. PS and force main. However, under this scenario, a portion of the wastewater flows tributary to the Deer St. PS will be re-routed to the PIT WWTF and therefore, an automated flow re-direction manifold structure will be required to accomplish a split flow regime from the Deer St. PS and is discussed below. Phasing of the upgrades is a consideration and will be addressed in a subsequent TM. The following sections discuss the modifications.

5.8.2.1 Sewer Pumping Stations and Force Mains

Gosling Road PS Force Main

Based on it's proximity to the PIT WWTF, the Gosling Road PS sewer-shed will be redirected to the PIT WWTF. The Gosling Rd. PS was constructed in 1970 and upgraded in 2004. The station is located off the eastern end of Gosling Rd. and is a wet well/dry well configuration. The station conveys flows via an 8-inch force main to the Woodbury Ave. interceptor in the vicinity of the K-Mart Plaza and ultimately by gravity to the Deer Street PS. The PS was evaluated and upgraded in 2004. During this upgrade an evaluation was completed that concluded that the 8-inch force main could be extended directly to the PIT WWTF. Recommendations included a 10-inch force main extension across Woodbury Ave. along Arthur Brady Dr. with directional drilling or jacking of the force main to the PIT WWTF, all shown on Figure 5-37.

The planning level cost to extend the force main to the PIT WWTF is $ 525,000.

Atlantic Heights PS Force Main

The Atlantic Heights PS was constructed in 1986 as part of a sewer separation project and serves the Atlantic Heights area to the north of the Springfield Terminal railroad corridor and west of I-95 along the Piscataqua River. The PS has a peak capacity of approximately 0.4 MGD. The existing force main currently discharges to a gravity sewer tributary to the Leslie Dr. PS where flow is pumped through Deer St. and Mechanic St. PSs to Peirce Island. The force main discharge location is within close proximity to a gravity sewer tributary to the Gosling Rd. PS in the Spinnaker Point neighborhood.

Since the Atlantic Heights sewer-shed is a separate sanitary sewer system, and due to the proximity to the Gosling Rd. sewershed, it is prudent to consider structural modifications in the system to shed flow from the combined sewer system. These flows would then be conveyed through the Gosling Rd. PS to the PIT WWTF. Based on a preliminary hydraulic analysis, the force main can be increased one pipe size and extended approximately 3,300 linear feet along Kearsarge Way, Mangrove St., and Spinnaker Way to Staysail Way where it would discharge into an existing sewer tributary to the Gosling Rd. PS. As identified earlier in this section, the Gosling Rd. PS force main will be re-directed to the PIT WWTF as shown on Figure 5-38.

The planning level cost to extend the force main to the existing gravity sewers tributary to the Gosling Rd. PS is $475,000.

Lafayette Rd. PS and Force Main

The Lafayette Rd. PS is located on the eastern side of the Route 1 Bypass near Greenleaf Woods Rd. The station was originally constructed in the late 1960's and receives wastewater flows from the southern portion of the City and the Town of Rye. The tributary areas to the PS are **not** combined; however, historic flow metering and previous studies have shown a significant wet weather flow contribution. Previous studies have identified considerable growth with associated peak flows. The PS conveys flow through a force main along the Route 1 Bypass and Lafayette Rd. to a gravity sewer near Willard Ave. The gravity sewer travels through the Lincoln Ave. combined sewer system to the Mechanic St. PS. Planning efforts associated with TM 3 and TM 4 have indicated that design year flows for this sewer-shed will require a PS capacity of 3.5 MGD

Due to the age and condition of the existing pump station, a new wet pit/dry pit PS would be constructed adjacent to the existing station. The PS would be designed for 3.5 MGD and a new 16-inch force main would be constructed to convey flow to the PIT WWTF. The force main would be constructed along the Route 1 Bypass to the rotary (traffic circle). It is anticipated that directional drilling of the force main will be required to take the force main under the rotary and to the west of I-95. From that point the force main would be constructed along Route 16 to a location were a second directional drilling operation would be necessary to reach the PIT WWTF. These modifications are shown in Figure 5-39. The cost for modifications to the Lafayette Rd. PS and force main under Scenario 2 are included in the following section as part of the costs for the Borthwick Ave. PS modifications.

Borthwick Ave. PS

The Borthwick Ave. Interceptor collects separated wastewater flows from portions of Greenland Rd. (Route 33)/Sherburne Ave. area, and along the southern end of Borthwick Ave., and conveys those flows to the Deer St. PS. This scenario has been developed to reduce separated wastewater flows from entering the combined sewer system. Flows from the southern sections of Borthwick Ave. have been estimated based on flow metering completed under TM 4 and are estimated to be 0.33 MGD ADF with peak flows of 1.0 MGD. For the purposes of this TM, a new submersible type PS would be sited along the Borthwick Ave. Interceptor in the vicinity of the Route 1 Bypass. The PS force main would connect to the force main from the Lafayette Rd. PS. Based on hydraulic considerations, the force main size would increase from 16-inches to 18-inches to accommodate the additional flow.

The planning level cost for the Lafayette Rd. and Borthwick Ave. PS's and force main to the PIT WWTF is $ 7,900,000.

Deer St. PS and Force Main

The Deer St. PS is the second largest PS in the City and is located at the corner of Deer St. and Market St. Wastewater from Gosling Rd., Atlantic Heights, Leslie Dr. Maplewood Ave., Borthwick Ave. and the Deer St. Box Sewer (Islington and Bartlett St. areas) sewer shed's are tributary to the pump station. The PS underwent a major upgrade in 2008 to increase capacity to 12.5 MGD. Based on flow metering and the upgraded hydraulic model completed in TM 4, wet weather peak flows can activate CSO 13 adjacent to the pump station. However, activation events have declined over recent years as a result of the increased hydraulic capacity of the station and the reduction in peak wet weather flows due to the completion of sewer separation projects with the tributary sewer-sheds.

The intent of Scenario 2 is to convey a portion of the wastewater flows to the PIT WWTF. This would require the design and construction of an automated flow re-direction manifold either within the existing pump station, or, in a concrete vault on Market St. The automated manifold would include isolation valves, magnetic flow meters, automated flow control valves, and controls/instrumentation to convey wastewater flows to either the PIT WWTF or the PI WWTF based on specific treatment capacities.

In order to convey flow to the PIT WWTF, a new force main would be constructed in a westerly direction along Market St. to Woodbury Ave., Arthur Brady Dr., and then crossing Route 16, to the PIT WWTF. Directional drilling may be required to cross North Mill Pond on Market St. and to cross Route 16 at the southern end of Arthur Brady Drive adjacent to the WWTF. A preliminary hydraulic evaluation concluded that a 30-inch force main would be required to convey the 12.5 MGD of peak wet weather flow to the PIT WWTF. As previously discussed in this section, modifications to the Gosling Rd., Atlantic Heights, Lafayette Rd. and inclusion of a new Borthwick Ave, Interceptor PS will reduce base sanitary and peak wet weather flows from the Deer St. PS sewershed.

During final design of the force main, consideration should be given to construction of two 20-inch force mains. This will allow for a phased implementation of the other components of the overall flow re-direction to the PIT WWTF. This is shown in Figure 5-40.

Because the Deer St. PS was recently upgraded with mechanical and electrical systems, it is not anticipated that major modifications will be required to re-direct the wastewater to the PIT WWTF. However, more detailed analysis will be required during the preliminary and final design phase.

The planning level cost for the automated flow re-direction manifold and dual force mains to the PIT WWTF is $4,100,000.

5.8.2.2 Gravity Sewer Lines

Under this scenario, no specific structural modifications are necessary to the existing gravity sewer lines. The ongoing sewer separation projects will continue to proceed based on the CD schedule. Additional improvements required as a result of system age were not identified within this technical memorandum and may occur.

Table 5-10 summarizes the pump station, force main, and gravity sewer system modification planning level capital costs for Scenario 2. These costs are based on 2010 costs and included 20% for engineering and 20% for contingencies.

Table 5-10 Scenario 2 Planning Level Capital Costs

Gosling Rd. PS force main extension	$525,000
Atlantic Heights PS force main extension	$475,000
Lafayette Rd. and Borthwick Ave. PS and force main	$7,900,000
Deer St. PS, automated flow re-direction, and dual force main	$4,100,000
Subtotal Capital Costs	$13,000,000

5.8.3 Scenario 3

Scenario 3 has been developed to eliminate the existing PI WWTF. Based on public input, it is the City's desire to remove wastewater treatment facilities from Peirce Island and increase the footprint of open space/parkland if possible. Previous sections of this TM have evaluated the treatment opportunities and restrictions at Peirce Island. This section of the TM identifies the changes to the existing collection and conveyance system necessary to convey wastewater, including a portion of the wet weather peak flows, to a new WWTF or an expansion of the existing PIT WWTF. For the purposes of TM 5, modifications to convey wastewater flow to the PIT WWTF will be discussed. The same modifications have been evaluated for a new WWTF in the vicinity of the Sprague Terminal/PSNH Woodchip Facility to the west of Portsmouth Blvd, and Dunlin Way. Figure 5-41 shows a schematic of required modifications under Scenario 3.

5.8.3.1 Sewer Pumping Stations and Force Mains

Section 5.8.2.1 discussed modifications necessary to re-direct flows from the outlying sewer-sheds to the PIT WWTF. These changes would also be required in a phased approach as part of a complete relocation of all wastewater flows from Peirce Island. These modifications included:

- Gosling Rd. force main extension
- Atlantic Heights force main extension
- Lafayette Rd. PS upgrade and force main relocation
- Borthwick Ave. PS and force main (combined with Lafayette PS force main)
- Deer St. automated flow re-direction manifold and force main

Additional PS and force main modifications include the following.

Deer St. PS and Force Main

As previously discussed under Scenario 2, the Deer St. PS will be redirected to the PIT WWTF under this scenario. During implementation of Scenario 3, phasing of flows to the upgraded/expanded PIT WWTF may necessitate the utilization of the aforementioned automated flow re-direction manifold. Therefore, under Scenario 3, the pump station, flow control manifold and force main modifications are also included under Scenario 3.

The planning level cost for the automated flow re-direction manifold and dual force mains to the PIT WWTF is $4,100,000.

Mechanic St. Dry Weather PS

Sanitary flows within the existing Mechanic St. sewershed will need to be re-directed to the Deer St. PS under this scenario. Ultimately, the existing Mechanic St. PS would become a wet-weather only PS which would convey peak wet weather flows to the existing primary WWTF on Peirce Island which will be operated as a wet weather CSO facility. The completed, ongoing, and future sewer separation project that are part of the current LTCP will continue to reduce peak wet weather flows based on the documented success concluded by the recent flow metering and completion of the updated hydraulic model discussed in TM 4.

In order to separate base sanitary flows during average conditions, a custom designed flow diversion structure will be required on the existing 36-inch gravity sewer upstream of the Mechanic St. PS. The Flow Diversion Structure (FDS) would be designed to convey the base sanitary flows identified in the hydraulic model based on the completion of the currently scheduled sewer separation projects in the Lincoln Ave. sewershed. During wet weather events, peak flows will pass through a self cleaning, weir-mounted fine-screen (1/4-inch opening) and flow by gravity to the Mechanic St. PS. Base sanitary flow and screenings will flow by gravity to a new submersible type PS adjacent to the Peirce Island Bridge. The submersible PS wetwell will include a sewage grinder to macerate all screenings/solids prior to pumping. Based on the available footprint and location, a mechanical screening component is not recommended. A submersible type PS was selected based on the available footprint and for the aesthetic aspects due to the proximity to Prescott Park. The standby power equipment and controls could be housed in a small structure with architectural consideration for the area. Figure 5-42 shows a schematic of the FDS.

The required PS capacity is 2.0 MGD which includes the projected base sanitary flows with minor wet weather peaks, wastewater flows from Newcastle, New Hampshire, and residual/wash-down flows from a wet weather facility on Peirce Island, which would now be used exclusively for CSO treatment. A 12-inch force main will be required to convey these flows to the Deer Street PS and subsequently to the PIT WWTF. The force main route will mirror the existing gravity line from Deer St. Based on discussions with the City, 2,100 linear feet of force main will be required as the force main can be connected 1,500 linear feet of the existing force main. See Figure 5-43. The new force main will travel from the PS along Mechanic St., along Marcy St., crossing State St., to the existing force main in the vicinity of Bow St.

The planning level cost for the Mechanic St. Dry Weather PS, FDS, and force main is $4,650,000.

Peirce Island Newcastle and CSO Residual/Washdown PS

Wastewater flow from Newcastle is pumped directly to Peirce Island via a sub-aqueous force main from Newcastle Ave. to the existing PI WWTF headworks. Scenario 3 removes all sanitary wastewater flows from Peirce Island thus allowing the existing facility to be retrofit to a CSO wet weather only facility. However, a CSO wet-weather facility will generate residuals during wet weather events. Also, once a wet weather event is over, the facility will require a washdown which will generate wastewater that must be conveyed off the Island. Based on anticipated wet weather facility design residual loadings, the permitted capacity for Newcastle flows, and washdown flow rates, a design capacity of 0.5 MGD is estimated for Peirce Island PS. Preliminary assessments of the existing site, along with the ability to drain potential wet weather treatment facility tanks via gravity and to allow for the potential for using existing subsurface structures for the PS have indicated that a combined washdown water booster station and wastewater PS adjacent to the filter building and chlorine contact chamber.

As shown on Figure 5-43, a 3,200 linear foot 6-inch force main would convey flows from the new Peirce Island PS to the Mechanic St. Dry Weather PS along Peirce Island Rd. crossing the bridge and discharging upstream of the sewage grinder..

The planning level cost for the Peirce Island PS and force main is $1,925,000.

5.8.3.2 Gravity Sewer Lines

The gravity sewer lines were evaluated as part of previous planning efforts. As previously noted, the City is proceeding with the implementation of the LTCP which will continue to reduce wet weather peak flow conditions. Hydraulic modeling completed in TM 4 has identified peak flow restrictions in the Parrott Ave. Interceptor downstream from CSOs 10A and 10B. Therefore, an upgrade in the hydraulic capacity of this interceptor is required. The existing interceptor is located along Parrott Avenue and travels through Strawberry Banke and Prescott Park to Marcy St., and ultimately to the Mechanic St. PS.

Planning level options include construction of a deep rock tunnel, a 36-inch relief interceptor, and a 54-inch replacement interceptor. A preliminary evaluation and planning level cost of a deep-rock tunnel determined the option not to be cost-effective. Due to construction in this historic area of the City, alternative alignments for a relief interceptor should be considered during a preliminary design evaluation. For the purposes of this TM, a 54-inch replacement interceptor has been considered. The interceptor would be constructed adjacent to the existing interceptor to reduce or eliminate bypass pumping requirements. Construction costs are estimated to be high due to the historic nature of the area. Final design considerations will require significant archeological and geotechnical investigations.

The planning level cost for debottlenecking the Parrott Ave. Interceptor is $2,300,000.

Table 5-11 summarizes the pump station, force main, and gravity sewer system modifications necessary to implement Scenario 3.

Table 5-11 Required Collection System Modifications Under Scenario 3

Gosling Rd. PS force main extension	$525,000
Atlantic Heights PS force main extension	$475,000
Lafayette Rd. and Borthwick Ave. PS and force main	$7,900,000
Deer St. PS, automated flow re-direction, and dual force main	$4,100,000
Mechanic St. dry weather PS, flow diversion structure and force main	$4,650,000
Peirce Island/Newcastle and CSO residual/washdown PS and force main	$1,925,000
Parrott Ave. de-bottleneck	$2,300,000
	$21,875,000

5.9 CSO ABATEMENT

5.9.1 Review of 2005 LTCP

The 2005 LTCP was an update of an earlier CSO Facilities Plan that was prepared for the City by Whitman & Howard in 1991 in response to a CD in effect at the time. That plan was never officially approved and, following a directive by EPA in 1998, the City embarked upon a formal LTCP process.

The 2005 LTCP built upon earlier system characterization, CSO and ambient monitoring and collection system modeling from the 1991 plan. The 2005 plan contained an updated listing and extensive evaluation of potentially-viable CSO abatement alternatives. The plan also addressed the issue of potential adverse water quality impacts from the discharge of separate stormwater resulting from sewer separation.

It should be noted that the City did not remain idle between the 1991 and 2005 CSO plans and began to address problems within the collection system through sewer rehabilitation and targeted separation of combined sewers. The 2005 LCTP documented these earlier collection system improvement efforts including both planning and implementation.

A summary of the plan's recommendations are as follows:

- Continue with targeted sewer separation for both CSO abatement and to address localized flooding and related capacity problems.
- Upgrade the Deer St. and Mechanic St. PSs to maximize wet-weather conveyance to the PI WWTF with its rated peak wet-weather capacity of 22 MGD.
- Build and measure: revise the 2005 LTCP following the 15-year targeted sewer separation program.

- If further CSO abatement is warranted following the targeted sewer separation program, a so-called "Plus Project" would be implemented. The Plus Project could include, but not be limited to: in- or off-line storage, satellite CSO treatment, expanded treatment at Peirce Island, or further sewer separation.

Collectively, the targeted sewer separation and PS projects were considered the Phase 1 CSO Projects; if needed, the future Plus Project would represent Phase 2. This phased concept represented a good example of "build and measure" and will continue into the 2010 LTCP Update.

The Plus Projects that were identified in the 2005 LTCP, and possibly others, will be revisited as part of this 2010 LTCP Update. Further, as with the earlier 1991 CSO Facilities Plan and 2005 LTCP, the PT WWTF will remain a key component of the 2010 LTCP Update with respect to further CSO abatement.

5.9.2 Update of Collection System Model and CSO Characterization

TM 4 contained a description of the current status of the City's combined collection system with an emphasis on:

- Improvements that were made to the collection system as a result of the 2005 LTCP recommendations and as well as those that were initiated prior the plan completion and approval.
- Ongoing and planned improvements to the collection system as a result of the 2005 LTCP.
- Updates that were made to the collection system hydraulic model to reflect the collection system improvements as documented by a comprehensive monitoring program that occurred in 2008.
- Resultant changes in CSO characterization statistics.

The system model and CSO characterization are closely linked: as improvements are made to collection system, and CSO activity is reduced, the model needs to be updated to reflect both the resultant physical and hydraulic changes in order for it to remain a reliable planning tool for further CSO abatement planning as required for the 2010 LTCP Update. These interdependencies are further described below.

5.9.2.1 Status of Collection System Improvement

TM 4 contains a summary description of the collection system improvements that have been completed to date, along with ongoing and planned projects. These projects, many of which originated from the 2005 LTCP planning process, have resulted, and will continue to result, in significant reductions in the annual volume of untreated CSO discharges at both CSOs 010A/010B at South Mill Pond and CSO 013 at the Deer St. PS and Pistacaqua River. The specific reductions in CSO activity resulting from these improvements are described later in this section.

5.9.2.2 Collection System Model

One of key elements in revising and updating the 2005 LTCP into the 2010 LTCP Update is the collection system model. The collection system model was originally developed for the 1991 CSO Facilities Plan and later updated for the 2005 LTCP. The model has since been updated to reflect both the numerous physical and hydraulic changes that occurred throughout the collection system. In addition, the model was updated to reflect projected changes in demographics, such as population and employment trends, and their attendant changes in wastewater generation. The latter was presented in TM 3 while the update of the model itself was presented in TM 4.

Also discussed in TM 4 were descriptions of, and the results from, a comprehensive flow monitoring program that was conducted in 2008 which employed: rainfall gauges; collection system and CSO flow meters; and pump station magnetic meters. The updated model was then used to determine the current CSO characterization statistics.

5.9.2.3 CSO Characterization

Following the update of the collection system model, the CSO characterization was then established to reflect the improvements that were made to the collection system, as documented in the 2008 monitoring program. Typical-year reductions in CSO activity as the result of completed projects, as documented by the monitoring, and ongoing collection system improvements, as projected by the model, were summarized in Table 4.8 of TM 4. The findings were as follows:

- 53% annual reduction of untreated discharge into South Mill Pond from CSOs 010A/010B – 9.4 MGal to 4.4 MGal.
- 86% annual reduction of untreated discharge into the Piscataqua River from CSO 013 – 3.7 MGal to 0.5 MGal.

Table 4.9 of TM 4 contained projections of further typical-year CSO reductions following collection system improvements that were planned beyond the ongoing projects. These projections revealed that during the typical-year, the annual discharge into South Mill Pond from CSOs 010A/010B will be reduced to 2.1 MGal/year; the model predicted that there would be no discharge to the Piscataqua River from CSO 013 in a typical year.

These results clearly indicate that the 2010 LTCP Update will be addressing a much lower base volume of annual CSO discharge than had the earlier CSO plans. A graphical representation of these two sets of results was shown in Figure 4.26. Thus, for the purposes of this TM, the primary focus will be placed on further abatement of the South Mill Pond CSOs.

5.9.3 Integration of LTCP and WWTF Planning

One of major differences between the 2010 LTCP Update and that of its predecessors, the 1991 CSO Facilities Plan and 2005 LTCP, is that a higher percentage, up to and including the entire 22-MGD peak capacity, of the PI WWTF could become available for CSO abatement. The extreme scenario of all 22 MGD becoming available for CSO flows would occur should it be determined that secondary treatment of the City's wastewater should take place at either the PIT WWTF site or an entirely new site, such as the so-called Sprague/PSNH site. A mid-range scenario would be where some of the flow is diverted to the PIT WWTF or a new site. Thus, the two parallel planning tracks of WWTF and CSO abatement are closely linked. Taken further, should the PI WWTF become available exclusively for CSO abatement, it would become a strong candidate for the so-called Plus Project as described in the 2005 LTCP.

As discussed earlier in the TM, there are three scenarios for the location of the upgraded PI WWTF and each having a direct impact on the available capacity for continued CSO treatment at the facility. Table 5-12 shows the resultant available peak instantaneous capacities for CSO treatment under these scenarios.

Table 5-12 Available Peak Instantaneous CSO Abatement Capacity under Alternative PI WWTF Upgrade Scenarios (2030 Conditions)

Scenario 1: Upgrade at Peirce Island	Scenario 2: Upgrade at Peirce Island and PIT	Scenario 3 Upgrade at PIT or Sprague/PSNH
10 MGD	14 MGD	22 MGD

Scenario 1 essentially represents current conditions, as projected to 2030, and assumes that the upgraded WWTF would remain on the Island. With this scenario, no additional capacity would be available for CSO treatment beyond what is currently available. Further, while the 2005 LTCP evaluated increasing the advanced-primary capacity to 36 MGD, space for this expansion would likely not be available under Scenario 1 if the WWTF was upgraded for both secondary treatment and nitrogen removal.

Scenario 2 represents shedding of a sufficient amount of flow to the PIT WWTF so that the upgrade could occur on Peirce Island at a reduced design flow to match the available build-out area. Under this scenario, the PIT WWTF would also need to be expanded, and upgraded, accordingly. Scenario 3 represents the removal of all non-CSO treatment functions from Peirce Island with the result that all 22 MGD of capacity would be available for CSO treatment. The required collection system and pump station redirection components to accomplish each of these scenarios are described earlier in the TM.

The available CSO treatment capacities on Peirce Island under these scenarios will become baseline considerations as CSO abatement measures are evaluated below.

5.9.4 Sizing CSO Abatement Facility for Scenarios

An analysis was performed to determine the size of the CSO abatement facilities needed for each of the scenarios. The goal of the analysis was to size facilities for a *reasonable* level of control, applied uniformly across the scenarios. *It is important to note that this level of control is only being used to assist in the selection of a preferred alternative.* Once the preferred scenario has been selected, additional analysis will be performed in future tasks to select an appropriate final level of control for the City's CSO facilities using processes and procedures described under both the Presumptive and Demonstrative Approaches of the 1994 CSO Control Policy, also described in TM 2.

A one-year level of control was deemed to be a reasonable level of control for the purposes of evaluating the scenarios. A number of large storm events were witnessed during the flow monitoring period of 2008. The event which occurred on June 15, 2008 produced the largest measured overflow volume during the monitoring period and had intensities and duration consistent with a 1-year storm[1]. This storm was selected for evaluating the sizes of the CSO abatement facilities for the scenarios.

Hydraulic models were developed to represent the Scenarios. The hydraulic model for Scenario 1, the scenario under which the collection system remains largely unchanged, corresponds to the model described in TM 4. Additional hydraulic models were developed for Scenarios 2 and 3. A model was also developed as a variation on Scenario 3. Like Scenario 3 this variation entails no secondary treatment on Peirce Island with all wastewater flows being diverted to a wastewater treatment facility to the west. However, unlike Scenario 3 which presumes the availability of the PI WWTF for treating wet-weather flows, this variation assumes that all existing WWTF facilities on Peirce Island will be removed. This variation of Scenario 3 represents a "completely off Peirce Island" scenario.

The flows used in the analysis take into account anticipated reductions in combined flows resulting from planned separation projects (see TM 4). Aside from the planned wet-weather projects, it was assumed that wet-weather flows will remain at current levels. This is consistent with the assumption that increases in wet-weather flows in the future due to system deterioration will be offset by the City's efforts to reduce and control extraneous flows. The flows correspond to population and commercial/industrial/ institutional development conditions in the year 2030.

[1] The total rainfall during the event was 2.5 inches. The storm was consistent with a 1-year storm across a range of durations. It was equivalent to a 1-year storm with a 1-hour duration, an 8-month storm with a 2-hour duration, a 1.5-year storm with a 3-hour duration, and 1-year storm with a 4-hour duration.

The results of the model runs are shown in Table 5-13. Under Scenario 1, CSOs 010A and 010B discharge approximately 2.9 MGal and have a peak flow of 18.2 MGD. Scenario 2, which includes a debottlenecking line from CSOs 010A and 010B to the Mechanic Street PS, is anticipated to have no CSO discharge. However, if Scenario 2 does not include a debottlenecking line, a CSO discharge of 0.3 MGal is expected, along with a peak flow of 4 MGD. No CSO discharge is expected under a Scenario 3 with 22-MGD of wet-weather treatment available on Peirce Island. However, if no wet-weather treatment is available on Peirce Island, a CSO discharge of 8 MGal is expected along with a peak flow of 26.6 MGD. The information presented in Table 5-13 forms the basis for the sizing of the CSO abatement facilities which will be discussed in subsequent sections.

Table 5-13 Characteristics for CSOs 010A/010B Under Scenarios 1, 2 and 3[1,2]

Scenario	CSO Volume at 010A/010B (MGal)	Peak Flow at 010A/010B (MGD)
1	2.9	18.2
2	0[3], 0.3[4]	0[3], 4[4]
3	0	0
No wet-weather treatment on Peirce Island	8	26.6

Notes:

[1] CSO characteristics for the June 15, 2008 storm, (equivalent to a 1-year storm) under 2030 development conditions. Flows take into account anticipated reductions from planned separation projects.

[2] CSO 013 was not active.

[3] Represents conditions with 54-inch debottlenecking line from the CSOs to the Mechanic PS.

[4] Represents conditions without any debottlenecking downstream of the CSOs.

5.9.5 Available CSO Abatement Measures

5.9.5.1 CSO Abatement Objectives

As was discussed earlier in TM 2, the goal of this and previous CSO planning efforts was to bring the CSO discharges into compliance with EPA- and NH DES-administered laws and regulations pertaining to CSO abatement and water quality standards. The key pollutants of concern to the CSO discharges in Portsmouth remain the control of floatable solids and fecal coliform bacteria reduction. Thus, as a minimum, all technologies and practices will need to address these pollutants.

As mentioned previously, the control level will be determined using processes and procedures described under both the Presumptive and Demonstrative Approaches of the 1994 CSO Control Policy later in the planning process following the selection of preferred technology in this TM. For the purposes of this TM, the initial targeted abatement goal is the 1-year, 2-hour design storm; it was selected as the starting point for later optimization, using a "knee-of-the-curve" approach, as the WMP process proceeds.

5.9.5.2 Available Technologies and Practices

CSO abatement technologies and practices are generally grouped by their functional application and fall into the following seven categories:

- Source Control/Volume Reduction Measures
- Sewer Separation
- Floatables Control/Screening.
- Storage.
- Co-Treatment at a centralized WWTF
- End-of-Pipe (Satellite) Treatment
- Disinfection

Technologies denote a physical and/or chemical treatment process while practices relate to non-technology measures, such as collection system management, operations and maintenance. A comprehensive listing and description of currently-available CSO abatement technologies and practices, grouped by these seven categories, are contained in Table 5-14.

As part of the WMP process, a CSO Technologies Workshop was held on August 13, 2008, at which time these technologies and practices were discussed with City staff along with representatives from both EPA and NH DES. The formal workshop presentation is included in Appendix F.

The technologies and practices are further discussed below along with their current application by the City if applicable.

Table 5-14 CSO Abatement Technologies and Practices

Technology/Practice	Remarks
Source Control/Volume Reduction Measures	*Aimed at volume and pollutant reduction.*
Best Management Practices (BMPs)	BMPs include EPA's Nine Minimum Controls (NMCs).
Sewer Rehabilitation	Aimed at reduction of infiltration/inflow (I/I).
"Green" Construction/Retrofits	Includes low-impact development, green roofs, rain barrels, infiltration basins, etc.
Water Conservation	Such as low-flush toilets; aimed at reduction of base sanitary flow.
Water Reuse	Potential seasonal limitations.
Sewer Separation	*Treatment of resultant storm drain discharges needs to be considered; can include partial (public inflow only) or total separation (public and private inflow).*
New Sanitary Lines	Results in new sanitary sewer infrastructure.
New Storm Lines	Sanitary sewers remain in tack unless rehabilitation included.
Floatables Control/Screening	*One of the NMC (No. 6); screening can also be considered end-of-pipe treatment.*
Baffles	Limited data on effectiveness.
Net Bags	Requires labor-intensive operation and maintenance (O&M).
Manual Screens	Must consider possible flooding/backups.
Mechanical Screens	Screenings can be automatically diverted back to sewer/WWTF.
Skimming devices	Site restrictive.
Storage	*Temporary holding of combined flow for later conveyance/treatment.*
Retention/Treatment Basins (RTBs)	Also called Overflow Retention Facilities (ORFs); combination of storage and primary treatment.
In-line Storage	Full utilization of system capacity is also a NMC (No. 2).
Near Surface Conduits for Conveyance/Storage	Combines conveyance with storage.
Tunnels for Conveyance/Storage	Combines conveyance with storage.
Off-line Storage	See also RTBs.

Table 5-14 CSO Abatement Technologies and Practices (con't.)

Technology/Practice	Remarks
Co-Treatment at WWTF	*Both within the WWTF and separate treatment at the WWTF site.*
Full Treatment	Peak wet-weather flows from combined sewers do not require full secondary treatment.
Full Treatment with Process Modification/Optimization	Such as hydraulic debottlenecking, step feed, contact stabilization, biological contact, etc.
Partial Treatment	Both with and without blending of the effluents.
Separate Wet Weather Treatment Facility	Using one of the end-of-pipe (satellite) technologies in 6; both with and without blending of the effluents.
End-of-Pipe Treatment	*Also considered to be satellite treatment.*
Primary Treatment	As defined by MOP 8 and elsewhere; see also RTBs.
Chemically-Enhanced Primary Treatment (CEPT)	Performance between primary treatment and Ballasted Sedimentation.
Vortex Separation	Aimed at primary treatment equivalency.
Ballasted Sedimentation	Such as Actiflo® or DensaDeg®.
Compressed-Media Filters	Requires equivalent of primary treatment as pretreatment.
Disinfection	*Can be coupled with technologies listed in 3, 4, and 5 plus RTBs.*
Chlorination/Dechlorination	Most common practice due to TSS in treated effluent.
UV	Requires high degree of pretreatment, such as Ballasted Sedimentation or Compressed-Media Filters; will be a challenge for current NPDES limit of 14 colonies FC/100 ml.
Bromochlorodimethylhydantoin (BCDHM)	Dry-powered form of bromine.

5.9.5.3 Current Practices

The City of Portsmouth is currently implementing a number of practices and abatement measures that are listed in Table 5-14 including:

- As was described in TMs 2 and 4, the City is implementing source control measures through its Nine Minimum Control (NMC) program which began in 1997. It has also recently begun to implement "green" retrofits into an ongoing sewer separation project on State St. Continued implementation of the NMC program and related source controls will be an integral component of the 2010 LTCP Update.
- Targeted sewer separation has been the primary focus of the City's abatement activities prior to and following the completion of the 2005 LTCP. As discussed in TM 4, these efforts are continuing and have resulting in significant reductions in annual CSO discharges and localized street flooding. As part of these programs, the City has also installed three stormwater treatment systems to reduce the pollutants from the separated stormwater discharges; a fourth will be installed as part of an ongoing project. Sewer separation beyond what is currently planned will be considered as the 2010 LCTP Update develops.
- Floatables controls, one of the NMC, has been continually implemented through three ongoing programs: BMPs, such as street and sewer cleaning and litter control; downstream stormwater treatment systems for recently-separated stormwater discharges; and removal and "sanitary" floatables through the actual separation work itself. Floatables control will also be considered as the 2010 LTCP Update develops in the context of the performance of the technologies under evaluation.
- Co-Treatment at the PI WWTF has been a key aspect of the City's CSO abatement program beginning in the early 1990s when the facility was upgraded to accommodate peak flows up to 22 MGD, well in excess of what was required for the City's base wastewater needs. As described throughout the TM, treatment at the PI WWTF will play a key role in the 2010 LTCP Update due to the necessity of the advance-primary facility to be upgraded to secondary, and the possibility of it being relocating to another site with adequate space for the upgrade.
- Disinfection, a key component of satellite treatment or co-treatment, is practiced at the PI WWTF and will be further evaluated in the 2010 LTCP Update with respect to both satellite treatment and further treatment at Peirce Island.

Technologies that were considered in the 2005 LTCP but are not currently practiced include:

- Storage, both in-line and off-line.
- End-of-pipe or satellite treatment.

Both storage and end-of-pipe treatment will be further evaluated in the 2010 LTCP Update, along with additional sewer separation.

Because of its key to the overall WMP, both with respect to WWTF upgrade and CSO abatement, the following discussion focused on the PI WWTF.

5.9.5.4 Peirce Island WWTF

The PI WWTF, a key component of CSO abatement for the City of Portsmouth since it was upgraded in the early 1990s, will remain a focus for the 2010 LTCP Update. As previously described, it could become the so-called Plus Project as defined in the 2005 LTCP, particularly if all or even a portion of the current dry weather flows are diverted to the PIT WWTF or an entirely new WWTF at the Sprague/PSNH site.

Use of the PI WWTF for CSO abatement has several advantages, not the least of which includes:

- The facility can accommodate 22 MGD of peak wet-weather flow.
- It provides an advanced-primary level of treatment.
- Its disinfection facilities are able to reliably meet the 14 col/100 ml FC limit for marine/shell fishing area discharges.
- The site and facilities are owned by the City.
- The existing Mechanic St. PS has the theoretical capacity to convey 22 MGD to the island.
- Additional capacity will be made available for CSO treatment as a portion or all of the dry weather flow is diverted to another WWTF.

There are, however, some negative aspects of using Peirce Island for CSO abatement, particularly if dry weather flows are treated elsewhere:

- Certain segments of the public may want all wastewater treatment operations removed from the Island.
- Due to its age and condition, the Mechanic St. PS and other required WWTF components will need to be refurbished in order to assure continued reliable operation.
- Grit removal and processing operations will need to remain on the Island for use during treatment events.
- Return flows associated with CSO treatment will need to be conveyed to the new, relocated WWTF for treatment; this includes dilute primary sludge during treatment events and tank cleaning and dewatering flows following treatment events.
- Flows from the Town of Newcastle will also need to be conveyed from the Island to the new WWTF.

The issue of public perception could be mitigated by transforming the site to better match a primarily recreational area. Such actions could include, but not be limited to:

- Removal of all unnecessary buildings and tankage, such as the dewatering building, the above-ground portion (or all) of the filter building, gravity thickener, sludge storage tanks, etc.
- Renovation of the required remaining building and structures to better match New England colonial-era architecture.
- Landscape around required remaining tankage – aerated grit tanks, clarifiers and chlorine contact tanks - to minimize their visual presence.

5.9.6 Other Technologies

In addition to further treatment at the PI WWTF, there are other viable technologies that were included in both the 2005 LTCP and discussed at the August 13, 2008 CSO Technologies Workshop that could apply to the 2010 LTCP Update. These, along with treatment at Peirce Island, are presented in Table 5-15.

Table 5-15 CSO Abatement Measures Considered for 2010 LTCP Update

CSOs 010A/010B	CSO 013
Additional Treatment at Peirce Island WWTF	Additional sewer separation (only as warranted following future build-out)
In-line Storage between Parrott Ave. and Mechanic St. PS	
Off-line Storage at Municipal Parking Lot	
End-of-Pipe Treatment/Disinfection with South Mill Pond discharge	
Additional sewer separation	

As was noted earlier, because CSO 013 is not predicted to overflow in a typical year, this technology evaluation will only primarily focus on the South Mill Pond CSOs (010A/010B). However, additional sewer separation remains under the CSO 013 column as additional reductions could be warranted, in the future, following the next build-out of abatement measures.

Each measure is further discussed below.

5.9.6.1 Additional Treatment at PI WWTF

The hydraulic model revealed that the PI WWTF, if dedicated for CSO treatment per Scenario 3, would abate the overflows at South Mill Pond CSOs (010A/010B) to the 1-year level of control with the addition of downstream hydraulic debottlenecking. Scenario 2 also provides a 1-year level of control. However, due to the availability of more wet-weather treatment capacity under Scenario 3, it is likely that Scenario 3 would provide a level of control in excess of 1-year while Scenario 2 probably would not.

While there would be no need for additional CSO abatement components under Scenarios 1 or 2 associated with the PI WWTF, Scenario 3 would include the need for several additional components including:

- A new parallel sewer and/or enlargement of the existing sewers would be required to debottleneck the hydraulic capacity of the lines between the South Mill Ponds CSOs on Parrott Ave. and the Mechanic St. PS in order to maximize the full amount of additional available capacity at the PI WWTF. Modeling has revealed that the existing line would need to upsized to a 54-inch diameter line.
- A new dry weather Mechanic St. PS would also be required to convey dry weather flow to the Deer St. PS for eventual treatment at the new WWTF. The existing Mechanic St. PS would be converted to handle peak wet-weather flows in excess of the capacity of the new dry weather Mechanic St. PS. Figure 5-41 shows a schematic drawing of the new flow patterns between the two PSs, including a new regulator or diversion structure described below.
- A new Flow Diversion Structure (FDS) would be required ahead of the new dry weather Mechanic PS that would regulate the amount of dry weather flow being pumped to the Deer St. PS; excess wet-weather flow would flow by gravity to the now dedicated wet-weather Mechanic St. PS. Figure 5-42 shows a possible layout of the FDS.
- In order to eliminate the need for screening at the PI WWTF, the diverted peak wet-weather flow would first pass through a weir-mounted fine screen (1/4-inch opening) in the FDS. The screen would be designed to direct all screenings into the wet well of the new dry weather pump station for conveyance to the Deer St. PS and ultimately, the new WWTF.
- An in-line grinder would be installed ahead of the new dry weather Mechanic PS wet well.
- As was previously discussed, a new Peirce Island PS would also be required to handle the return flows associated with CSO treatment: primary sludge during treatment events and tank cleaning and dewatering flows following treatment events. Flows from the Town of Newcastle will also need to be pumped from the Island via the new Peirce Island PS. The force main from the new PS would discharge upstream of the grinder at the new dry weather Mechanic PS wet well.

There are also a number of modifications to the PI WWTF that are required under the two scenarios. These are addressed under the WWTF portion of the TM for Scenario 2 as part of the larger, more expansive upgrade discussions while under Scenario 3 they would fall under CSO abatement. The specific modifications required under Scenario 3 include:

- The aerated grit tanks and processing systems would remain in service but refurbished as generally described in a Memo to Steven Clifton, UEI, from Steven Freedman, Brown and Caldwell, on the Peirce Island WWTF Headworks Evaluation, dated March 7, 2006. This memo is included in Appendix G.
- The primary clarifiers and disinfection system, including chemical systems, would remain in service, but require refurbishment.
- Other areas of required refurbishment include the primary clarifier splitter box, roof of the control building and the existing Mechanic St. PS.

- All sludge processing systems (gravity thickener, storage tanks, dewatering, etc.) and their support facilities and structures would be abandoned and could be demolished at a convenient time.
- During treatment events, unthickened or diluted primary sludge would be continually pumped back to the new dry weather Mechanic St. PS.
- Following a treatment event, the aerated grit tanks, clarifiers and disinfection tanks would be dewatered and cleaned with the contents pumped back to the new dry weather Mechanic St. PS.
- Flow from the Town of Newcastle would also be continually pumped from Peirce Island to the new dry weather Mechanic St. PS.
- The previously described new Peirce Island PS would perform these three pumping functions – dilute primary sludge, tank dewatering and Town of Newcastle. The new station could be located in the basement of one of the remaining buildings on the Island or be a stand-alone station.

The estimated cost to implement these modifications is shown in Table 5-16.

5.9.6.2 In-line Storage

In-line storage was considered in the 2005 LTCP for both the South Mill Pond and Piscataqua River CSOs. It remains a viable measure for the 2010 LTCP Update and could be designed into the new debottlenecking line between the South Mill Pond CSOs (010A/010B) and the Mechanic St. PS under Scenarios 2 and 3. As noted above, the upsized line, primarily for conveyance purposes versus in-line storage, would be 54-inches in diameter.

The new or upsized line could be further enlarged to provide in-line storage and also reduce or shave the peak flow rates upstream of the new FDS as part of the new dry weather Mechanic St. PS, required under Scenario 3. This optimization will be considered following the submittal of TM 5 and the preparation of the 2010 LTCP Update as part of the WMP.

5.9.6.3 Off-Line Storage

Off-line storage was considered in the 2005 LTCP for the open-air Municipal Parking Lot off of Parrott Ave. for CSOs 010A/010B. This measure remains viable under all scenarios and could be a stand-alone alternative or considered in combination with other measures, such as additional treatment at Peirce Island for Scenarios 2 and 3.

The components of an off-line storage tank facility for CSOs 010A/010B would include:

- New or modified CSO regulator chamber.
- Conduit from the new CSO regulator chamber to the off-line storage tank.
- Enclosed underground tank equipped with automatic flushing system consisting of tipping buckets or flushing gates and odor control.
- Pumps to dewater the tank and convey flow back into the Parrott Ave. sewer following the storage event.

The updated model revealed that a 2.9 MGal storage tank would be necessary under Scenario 1 and a 0.3 MGal storage tank under Scenario 2. However, installation of the debottlenecking line between CSOs 010A/010B and the Mechanic St. PS would preclude the need for the storage facility under Scenario 2. Layouts of off-line storage facilities at the open-air parking lot for these two scenarios are shown in Figures 5-44 and 5-45. The attendant cost estimates are presented in Table 5-16.

5.9.6.4 End-of-Pipe Treatment

End-of-pipe-treatment, followed by disinfection was considered in the 2005 LTCP for both CSOs 010A/010B and 013 and remains viable for the former. However, because of site constraints, and the desire for the treated effluent to have an effluent quality equal or better than what is discharged from the Peirce Island WWTF, the only satellite treatment process that will be considered under this TM is ballasted sedimentation, also referred to high-rate clarification (HRC). These would include the proprietary Actiflo® or DensaDeg® processes. These systems, although somewhat complex to operate, have a relatively small footprint and produce a high-quality effluent, nearly approaching that of secondary treatment. As with the 2005 LTCP, end-of-pipe treatment remains viable under all scenarios but primarily under Scenario 1 with its most limited amount available for wet-weather treatment capacity at Peirce Island.

The components of a typical HRC facility for CSOs 010A/010B would include:

- New or modified CSO regulator chamber.
- Conduit from the new CSO regulator chamber to the HRC facility.
- Fine screening (1/4-inch openings). The screen may be able to be located at the modified CSO regulator chamber such that the screenings are directed back to the Parrott Ave. sewer such that local handling is avoided.
- HRC units (minimum of two process trains for redundancy) consisting of chemical mixing and maturation tanks and settling tanks.
- Sludge recycle and waste pumps.
- Treated effluent pumps.
- Sludge thickener and liquid sludge storage tank.
- Disinfection system consisting of contact tanks for both chlorination using sodium hypochlorite and dechlorination using sodium bisulfite. Powered BCDHM could be considered as an alternate disinfection chemical during the design process.
- Chemical feed and storage systems for the coagulant (or metal salt such as ferric chloride), polymer, sodium hypochlorite and sodium bisulfite.
- Ballast storage, feed and recovery systems (microsand for Actiflo® only).
- Outfall to South Mill Pond.

For the purposes of this TM under Scenarios 1 and 2, it is assumed that the chemically-laden waste sludge would need to be thickened and stored on-site until the end of the treatment event to ensure that it would receive full secondary treatment when it reached the Peirce Island

WWTF. If HTC is used under Scenario 3, the solids could be directed to the dry weather Mechanic St. PS to ensure ultimate secondary treatment. It should be noted that these solids management scenarios would be applicable for all end-of-pipe satellite treatment alternatives, including vortex separation which was considered as a Plus Project in the 2005 LTCP.

The model revealed that the HTC system would need to be sized for a peak design flow of 18.2 MGD for Scenario 1 and 4 MGD for Scenario 2 without the debottlenecking line. The latter appears to be too small for a HTC and will be dropped from further consideration in lieu of the debottlenecking line, or a 0.3 MGal off-line storage facility.

A layout of an 18.2-MGD HRC facility in the vicinity of CSOs 010A/010B is shown in Figure 5-46. There would be two-25-MGD units, the standard size from the manufacture; one would be used for service and one as a stand-by unit. The facility would include the components listed above and would be located in the vicinity of the two CSOs. As shown, the HRC would be quite intrusive to the open spaces in the vicinity of CSOs as it would require both above- and below-ground structures. For example, while most of the tankage and related equipment – chemical mixing and flocculation, settling, sludge thickening and storage and sludge and effluent pumps - could be below grade, the controls, chemical storage and feed systems for the four required chemicals, odor control, and other processes would be above-grade. Because of these factors, and the large footprint, HRC will not be considered as a viable abatement technology for these CSOs. Another factor for dropping it from consideration would be the need for the treated effluent to remain in South Mill Pond, an already stressed water body.

5.9.6.5 Additional sewer separation

Additional sewer separation is viable for CSOs 010A/010B, and to a lesser extent CSO 013, as both stand-alone measures or in conjunction with other measures should additional abatement be warranted. The degree of additional sewer separation, beyond what the City is currently committed to performing, would be determined following the build-out of the next phases of the CSO abatement program. This build-and-measure approach would be consistent with the City's CSO abatement efforts as documented in the 2005 LTCP.

5.9.7 Summary

Based upon the previous evaluations it appears that the following abatement measures are most suitable for the South Mill Pond CSOs (010A/010B) for the three scenarios under consideration:

- Scenario 1 – 2.9 MGal Off-line Storage Tank or additional sewer separation
- Scenario 2 – Debottleneck Line between CSOs 010A/010B and Mechanic St. PS or additional sewer separation
- Scenario 3 – Debottleneck Line between CSOs 010A/010B and Mechanic St. PS plus miscellaneous PI WWTF improvements or additional sewer separation

For the purposes of this TM, the costs associated with off-line storage will be considered placeholders for Scenarios 1 and 2. For Scenario 3, complete treatment at the PI WWTF will be considered the placeholder. As such, the costs associated with these placeholders will be carried forward in the subsequent evaluation in lieu of additional separation. The final determination of the preferred abatement measures will be made during the development of the 2010 LTCP Update as part of the overall WMP.

Cost estimates of these scenarios are presented below.

5.9.7.1 CSO Abatement Costs

The cost estimates for the CSO abatement components for the three scenarios are presented in Table 5-16. The detailed spreadsheets used to develop these costs are included in Appendix E.

Table 5-16 CSO Abatement Capital Cost Components

Component	Scenario 1	Scenario 2	Scenario 3
Regulating Structure at CSOs 010A/010B	$0.2	$0.2	$0.2
Off-Line Storage Facility	$27.0M	$4.0M	N/A
Peirce Island WWTF Improvements:	N/A	N/A	$14.2 M
Total	$27.2M	$4.2M	$14.4M

Note: Flow redirection and debottlenecking costs for Scenarios 2 and 3 are included elsewhere.

These costs will then be combined with the previously-developed WWTF and flow redirection costs to develop the most cost effective overall program.

5.10 PHASED CONSTRUCTION APPROACH

The costs presented herein are significant and are unlikely to be affordable to the residents of the City of Portsmouth. An affordability analysis will be completed as part of TM 6, which will be prepared in 2010. Recognizing that affordability will be a significant issue to implementation, a phase construction approach has been considered. The phased approach is essentially Scenario 3. However, instead of completing all construction work in one short term program, the design and construction effort would be spread over time to reduce the financial impact.

If the PSNH/Sprague site were considered for a new WWTF, the City would be operating the PI WWTF, PIT WWTF and new WWTF simultaneously. Therefore, only the PIT WWTF has been considered as part of the phased approach.

5.11 FINDINGS AND RECOMMENDATIONS

5.11.1 Alternatives Cost Summary

Present worth is used to compare the life cycle costs for each scenario. Based on capital and O&M cost estimates shown previously, the present worth cost for each scenario are summarized in Table 5-17. These costs are based on a TN of 8 mg/L. Initial indications are that a TN of 5 mg/L or lower will result in an additional 30 to 40 percent increase in capital cost as well as additional operation and maintenance costs. The detailed spreadsheets for capital and O&M costs used to develop these present worth costs are included in Appendix E.

Table 5-17 Present Worth Estimates for WMP Scenarios for a TN limit of 8 mg/L

	PI WWTF Scenario 1	PI/PIT WWTFs Scenario 2	PSNH Scenario 3			PIT Scenario 3		
Technology:	SBR	SBR	SBR	MLE	IFFAS	SBR	MLE	IFFAS
	M$	M$	M$	M$	M$	M$	M$	M$
WWTF	158	238	146	145	153	145	141	144
Redirect/Shed	0	13	22	22	22	22	22	22
CSOs	27.2	4.2	14.4	14.4	14.4	14.4	14.4	14.4
Total	185.2	255.2	182.4	181.4	189.4	181.4	177.4	186.4

The lowest present worth costs determined are for Scenario 3, which offers several options for different BNR processes and WWTF location with similar estimated present worth costs. Because present worth costs are similar in many cases, a comparison of initial capital costs for each option under the WMP Scenarios is needed. A summary of the capital cost estimates for each option at a TN limit of 8 are presented in Table 5-18. As shown, for a TN limit of 8 mg/L, the lowest cost options are expanding the SBR system or building a new MLE system at the PIT WWTF under Scenario 3.

Table 5-18 Summary of Capital Cost Estimates for WMP Scenarios for a TN limit of 8 mg/L

	PI WWTF Scenario 1	PI/PIT WWTFs Scenario 2	PSNH Scenario 3			PIT Scenario 3		
Technology:	SBR	SBR	SBR	MLE	IFFAS	SBR	MLE	IFFAS
	M$	M$	M$	M$	M$	M$	M$	M$
WWTF	77 (1)	131	76	74	81	72	70	78
Redirect/Shed	0	13	22	22	22	22	22	22
CSOs	27.2	4.2	14.4	14.4	14.4	14.4	14.4	14.4
Total	104.2	148.2	112.4	110.4	117.4	110.4	106.4	114.4

1 - WWTF option not feasible since available technologies cannot fit within the setback limits on PI.

The capital cost is higher for a new SBR system at PSNH; this option has been discarded as less favorable than the other two options with similar present worth estimate. Similarly for the PIT

WWTF options under Scenario 3, both the SBR and MLE processes offer similar present worth and capital costs, but the SBR expansion option is considered more favorable because the existing SBRs could be re-used in a phased approach. There is also potential to increase process capacity in the existing and new SBRs with the addition of an emerging technology.

5.11.2 Recommendation

At this time, Scenario 3 using SBRs at the PIT WWTF is the preferred option of all scenarios developed and presented in this TM. It is recommended that a phased approach be considered under Scenario 3, pending the outcome of an affordability analysis and any future piloting of emerging processes. However, there are several areas where additional information could influence changing the recommendation of this TM to a different option.

The major area of concern that could influence a reevaluation of the preferred option is permitting for an 8.9 MGD outfall from the PIT WWTF. Permitting for an 8.9 MGD outfall at an affordable cost, in consideration of design and location as well as future effluent limits, are the most influential unknowns. The City is limited in its future decision-making ability until the permitting potential and likely future TN limits are known.

Moving sanitary wastewater treatment off of Peirce Island is the preferred option of the City. This honors the reaffirmed intentions of City residents, and allows the City to remove an industrial use from the City's historic and residential downtown. Moving sanitary treatment off of Peirce Island also preserves and protects the remains of Fort Washington.

Scenario 3 also allows for expansion as TN limits or other effluent limits may change over time. It will allow for potential future regional efforts for Wastewater treatment and/or sludge reuse and/or disposal. The lack of available land at Peirce Island limits future expansion possibilities if TN limits below 8 mg/L are incorporated into future permits.

Finally, Scenario 3 allows for a phased approach to design construction and implementation of secondary treatment. Such a phased approach not only makes the construction of a new facility potentially more affordable, but also has the benefit of delivering positive environmental impacts sooner rather than later by shifting some flow to utilizing existing capacity at the PIT facility. An expansion at PIT is not dependent on the viability of the emerging technology, BioMag™. If piloting of Bio-Mag is successful the City may have opportunity at PIT to reduce its costs. If Bio-Mag is not successful the City can still proceed with construction using more traditional technologies.

5.11.3 Regulatory Issues

Each Scenario presented in this TM has specific regulatory challenges.

Scenario 1 would reuse the existing PI WWTF outfall, and the combined sanitary and wet weather flow rate of 22 MGD would not change. However, an anti-degradation analysis may be required, since the permitted sanitary flow rate for the PI WWTF would increase. Anti-degradation requirements are provided in Appendix H.

In addition, with Scenario 1, unless the BioMag™ process (or other emerging technology) is used, setback waivers and or encroachment of historic resources associated with Fort Washington will be required to site the WWTF on Peirce Island. The US EPA would be the lead agency to participate in the Section 106 process relative to the impacts on the historic structures, should the City choose to modify and expand its treatment facility at Peirce Island.

Scenarios 2 and 3 would require additional flow from the PIT WWTF Outfall. Therefore, an anti-degradation analysis and CorMix modeling will be required. Shellfish closure areas are also a concern. There is a potential for expansion of current shellfish closure areas depending upon the time of travel between a possible WWTF disinfection system malfunction and the time it takes to notify the public of an emergency closure. The City is waiting for DES to finalize and release their Dye Study results which will define the potential closure areas.

In addition the recently released nutrient criteria and pending waste load allocation may impact capital costs for the various scenarios.

The governing body of the Town of Eliot, Maine has gone on record stating the Town is against increasing the flow from the PIT WWTF outfall. The Maine DEP may have some level of legal jurisdiction on this. In addition a private shellfish company has expressed concern over the relocation of flow up stream. These concerns are documented in a letter received by the City from Spinney Creek Shellfish, Inc. that is included in Appendix D.

If the anti-degradation or model findings indicate that an outfall in that area cannot be permitted, then the outfall would need to be relocated to either the Deer Street CSO area or to the current PI WWTF outfall location. This would add an estimated $5.8M to the project cost.

5.11.4 Next Steps

Pursuing Scenario 3, namely the removal of all sanitary flow from Peirce Island and expansion of the PIT WWTF, the City must undertake with regulatory input an anti-degradation analysis and CorMix modeling for the proposed PIT WWTF outfall expansion.

Based on recent input from the EPA, the anti-degradation analysis must be completed during specific tide cycles. The City estimates that this analysis would start the spring of 2010 and could require up to 24 months to complete, depending upon weather conditions and other factors outside the City's control. Criteria developed and recommended by NH DES for an anti-degradation analysis for the proposed PIT WWTF outfall expansion are provided in Appendix H.

The City will continue its affordability analysis and evaluate the impact on the implementation schedule to be developed. Assuming the final solution will be based on a phased approach, the cost for phasing must be developed. Initial estimates indicate that completing the program will result in user rates exceeding 2.5% of the median household income.

The City is undertaking a value engineering analysis of the scenarios outlined in this TM.